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Determination of Effects on Ambient Conditions on Aircraft Engine Emissions. ALF 502 Combustor Rig and Engine Verification Test

Avco Lycoming Div, Stratford, CT

Prepared for

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DETERMINATION OF EFFECTS OF AMBIENT CONDITIONS ON AIRCRAFT ENGINE EMISSIONS

ALF 502 COMBUSTOR RIG TESTING AND ENGINE VERIFICATION TEST

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Mobile Source Air Pollution Control
Emission Control Technology Division
Ann Arbor, Michigan 48105

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16. ABSTRACT

A program was conducted by Avco Lycoming Engine Group under Contract No. 68-03-2383 with the Evironmental Protection Agency for the purpose of determining the effects of ambient temperature, humidity, and pressure on the emissions of hydrocarbons, carbon monoxide, oxides of nitrogen, and smoke. The approach involved the performance of two tasks. Task I was to gather data through Lycoming ALF 502 combustor rig testing under controlled simulated inlet conditions; Task II was to test a full-scale ALF 502 engine over a range of uncontrolled ambient conditions to verify the rig test data. These data will be part of a data base collected by the EPA for the development of correction factors for gas turbine engine emissions.

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Prepared for

ENVIRONMENTAL PROTECTION AGENCY
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1 (a)

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Publication No. EPA-460/3-77-017

PREFACE

The investigation described herein was conducted by the Avco Lycoming Division, Stratford, Connecticut under EPA Contract Number 68-03-2383. The program period of performance was March 1976 through May 1977.

The objective of this program was to establish a data base from which the effects of ambient variations on gas turbine emissions can be evaluated.

The Avco Lycoming Project Officer was John Sherman. Harry Trembley was the Principal Investigator and was responsible for all combustor rig and engine verification testing. The EPA Project Officer was Tom Cackette. EPA Contracting Officer was Albert W. Ahlquist.

All processed data were transmitted for analysis to Paul Donovan and H. T. Adams of Calspan Technology Products.

Significant contributions made by Lycoming Engineering and Technical Staff are appreciated by the author.

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1.0 INTRODUCTION

The effort described in this report and the resulting data obtained were performed at the Avco Lycoming facility in Stratford, Connecticut, for the Environmental Protection Agency, Emissions Control Technology Division, Ann Arbor, Michigan under Contract No. 68-03-2383.

The Lycoming combustor facilities were used to generate emissions data of hydrocarbons, carbon monoxide, oxides of nitrogen, and smoke from an ALF 502 combustor rig test under controlled atmospheric conditions. The measured emissions reflected the variations due to humidity, ambient temperature, and barometric pressures which could then be applied to the actual engine operation and measurements.

An engine verification emission test was also conducted on the ALF 502 turbofan engine over a range of uncontrolled ambient conditions to confirm combustor rig results.

The resulting data from the program were submitted to the EPA for the purpose of developing correction factors for engine emissions data. The correction factors are to provide the means of standardizing engine emission data acquired under uncontrolled conditions to show compliance to the 1979 EPA Aircraft and Aircraft Engine Emission Standard.

2.0 SUMMARY

Seven test series were conducted to measure exhaust emissions on an Avco Lycoming ALF 502 turbofan engine covering a range of ambient conditions of temperature, barometric pressure, and humidity. Each test series included the seven engine power levels listed in Table 2-1; and the ambient conditions encountered are indicated in Table 2-2.

Using the same model combustor hardware (liner, fuel manifold, housing, and flow divider), three combustor rig emission test series were performed at idle, 1.5 times idle, and approach conditions. Each test series covered the wide range of controlled ambient conditions listed in Table 2-3. The corresponding combustor conditions can be found in Table 7-2.

The engine and rig emissions data including hydrocarbon, carbon monoxide, carbon dioxide, oxides of nitrogen and smoke were recorded, processed, and checked for validity and forwarded to the EPA and Calspan Technology Products for analysis and development of correction factors. Calspan Technology Products was the company chosen by the EPA to process the data obtained under this program and correlate and combine these results with similar data obtained from other engine manufacturers. The formats used for both engine and rig test data transmittal are shown in Figures 2-1 and 2-2.

TABLE 2-1. Engine Power Settings

Mode	Thrust
Taxi Idle	400 lb
1.5 x Taxi Idle	600 lb
Approach	30% of T.O.
Cruise No. 1	44.6% of T.O.
Cruise No. 2	52.3% of T.O.
Climbout	90% of T.O.
Takeoff	100% of T.O.
Standard Day Takeoff (T.O.) Power = 6500 lb	

TABLE 2-2. ALF 502 ENGINE TEST AMBIENT CONDITIONS

Test No.	Ambient* Pressure (psia)	Average Ambient Temperature (^oF)	Humidity Grains of H_2O (lb Air)
22	14.80	76.6	101.
23	14.80	70.9	114
24	14.71	76.	107.
25	14.62	77.6	124.
26	14.63	73.3	121.
27	14.68	78.5	111.
28	14.71	63.5	62.
Maximum	14.80	18.5	124
Minmum	14.62	63.5	62
Range	0.18	15.0	62

NOTES: Tabulated pressures are at engine idle condition. For engine inlet pressure at higher powers, including cell depression, see Appendix C, Engine Data.

TABLE 2-3. ALF 502 COMBUSTOR SIMULATED AMBIENT CONDITIONS

Test Point	Temperature		Humidity		Pressure	
	°C	°F	Grams H_2O/Kg Air	Grains H_2O/ lb Air	KP_a	H_g
1	-7	19	3.6	25	101.3	29.92
2	4	39	│	│	↓	↓
3	15	59	│	│		
4	29.5	85	│	│		
5	40.5	105	│	│		
6	4	39	5	35		
7	15	59	7.5	52.5		
8	29.5	85	7.5	52.5		
9	40.5	105	7.5	52.5		
10	15	59	10	70		
11	29.5	85	15	105		
12	40.5	105	15	105		
13	29.5	85	25	175		
14	40.5	105	25	175		
15	-7	19	3.6	25	109.32	32.28
16	15	59	7.5	52.5	↓	↓
17	40.5	105	3.6	25		
18	40.5	105	25	175		
19	-7	19	3.6	25	88	25.98
20	15	59	7.5	52.5	↓	↓
21	40.5	105	3.6	25		
22	40.5	105	25	175		

ENGINE DATA FORMAT

```
                                                                              051375
ENGINE TEST DATA
DATE                           DATA POINT        TEST CELL                    051375
5/12/75                        051375            13                           051375
INSTRUMENT OPERATOR                              TEST OPERATOR                051375
TREMBLEY                                         WALSH                        051375
ENGINE MANUFACTURER            MODEL             SERIAL NUMBER                051375
LYCOMING                       ALF-502           LF04                         051375
FUEL IDENT.                    FUEL FLOW PPH     MANIFOLD FUEL TEMP FAH       051375
JET-A HC RATIO 0.167           2000.             125.                         051375
BELLMOUTH AIR FLOW LB/SEC      CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.       051375
270.                           25.               .0156                        051375
PT3 PSIA                       TT3 DEG. RANKINE                               051375
80.                            713.                                           051375
PT9 PSIA                       TT9 DEG RANKINE   EPR                          051375
15.5                           1200.             8.0                          051375
NET THRUST LBS                 N1 RPM            N2 RPM                       051375
6500.                          18000.            7000.                        051375
ACTUAL INLET PRESSURE PO PSIA                                                 051375
14.7                                                                          051375
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                      051375
519.                                                                          051375
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           051375
25.0                                                                          051375
FILTER AREA .372 SI                                                           051375
CLEAN CK SMOKE NUMBER 1                                                       051375
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIG    TEMP. DEG.FAH     051375
          35.                3.          .5         3.0              230.     051375
          44.                4.          .5         3.0              230.     051375
          54.                7.          .5         3.0              230.     051375
          64.               11.          .5         3.0              230.     051375
GASEOUS EMISSIONS                                                             051375
                    FID          NDIR        NDIR        CHEMI      CHEMI     051375
                    UHC          CO          CO2         NO         NOX       051375
RANGE                1           3           3           2          2         051375
INSTR GAS TEMP      150.         55.         55.         55.        55.       051375
RAW VALUE MV        225.         400.        400.        750.       755.      051375
GAS CONCEN PPM(C)   179.5        534.        30567.      76.        80.       051375
GAS CONCEN PCT      0.0180       .0534       3.0567      .0076      .0080     051375
EMISSION INDEX      5.74         34.3        3077.       7.9        8.1       051375
FUEL-AIR RATIO      .0156                                                     051375
```

Figure 2-1. Engine Data Format.

COMBUSTOR RIG DATA FORMAT

```
COMBUSTER RIG TEST
DATE                                                                 051375
5/13/75                   DATA POINT          TEST CELL              051375
INSTRUMENT OPERATOR       051375              1                      051375
TREMBLEY                                      TEST OPERATOR          051375
ENGINE MANUFACTURER                           WALSH                  051375
LYCOMING                  MODEL               SERIAL NUMBER          051375
FUEL IDENT.               ALF-502             LF04                   051375
JET-A HC RATIO 0.167      FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH 051375
ORIFICE AIRFLOW LB/SEC    2000.               125.                   051375
25.                       PT3 PSIA            TT3 DEG.RANKINE        051375
SIMULATED THRUST LBS      100.                713.                   051375
6500.                     FUEL-AIR RATIO MEAS.                       051375
SIMULATED INLET PRESSURE PO PSIA.0156                                 051375
14.7                                                                 051375
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                           051375
519.                                                                 051375
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                  051375
25.0                                                                 051375
FILTER AREA .372 SI                                                  051375
CLEAN CK SMOKE NUMBER 1                                              051375
SMOKE NUMBER       VOL.-LITERS    FLOW-CFM PRESS.-PSIG  TEMP. DEG.FAH 051375
        35.              3.           .5         3.0           230.  051375
        44.              4.           .5         3.0           230.  051375
        54.              7.           .5         3.0           230.  051375
        64.             11.           .5         3.0           230.  051375
GASEOUS EMISSIONS                                                    051375
                  FID        NDIR       NDIR       CHEMI      CHEMI   051375
                  UHC        CO         CO2        NO         NOX     051375
RANGE              1          3          3          2          2      051375
INSTR GAS TEMP    150.       55.        55.        55.        55.     051375
RAW VALUE MV      225.       400.       400.       750.       755.    051375
GAS CONCEN PPM(C) 179.5      534.       30567.     76.        80.     051375
GAS CONCEN PCT    0.0180     .0534      3.0567     .0076      .0080   051375
EMISSION INDEX    5.74       34.3       3077.      7.9        8.1     051375
FUEL-AIR RATIO    .0156                                               051375
                                                                     051375
```

Figure 2-2. Combustor Data Format.

3.0 CONCLUSIONS

Combustor rig testing provides a successful method of simulating a wide variety of ambient inlet conditions to determine their effects on engine emissions. The accurate control possible over pressure, temperature, humidity, fuel and air flows allows accurate assessment of the resulting variations in emissions. (Para 11-4)

Correlation between engine and rig data is acceptable when combustor conditions are closely duplicated in both tests, as evidenced by the approach power setting. (Para 11-4)

Extrapolating the results of the engine performance computer deck to yield idle and 1.5 idle operating conditions resulted in rig test fuel-air ratios that did not correlate with the engine test. The rig idle fuel-air mixture is richer and the rig 1.5 idle is leaner than occured during the engine test. This resulted in a lack of good correlation with the engine data at these power settings but has no effect between the relationship of emission index to ambient condition variations. (Para 11-4.2)

The data obtained from this test program provide a satisfactory data matrix for developing correlating factors in the lower power settings. (Para 11-4)

The humidification and measurement system developed for this program provides a reliable method of humidity control for combustor rig tests. (Para 11-3)

The design techniques used for sizing and mounting of the gas sample probes in both the engine and rig test provided representative samples of the exhaust emissions, as demonstrated by the measured versus emission-based fuel-air ratio correlations (Para 11-2).

4.0 RECOMMENDATIONS

Consolidate the data obtained by Lycoming in this program with other existing data to obtain correction factors for ambient conditions. (Para 5.1)

Incorporate the factors developed into the EPA regulations to allow emission tests to be accomplished at other than standard day ambient conditions. The incorporation of these correction factors should be preceded by an industry-wide review to assure successful application. (Para 5.1)

Modify EPA regulations describing test techniques to increase the minimum time between sample line contamination checks to provide an economical procedure. (Para 8.8.3)

5.0 BACKGROUND AND APPROACH

5.1 PROBLEM STATEMENT

The variability of emissions levels from a gas turbine engine is of significant importance to both the engine manufacturer in meeting air quality standards and the EPA for setting these standards. Although many variables can effect the pollutants of an engine, ambient condition variations directly affect the engine operating parameters and, therefore, the emission levels.

The EPA regulations specify engine power setting for which the data is to be taken. The test power is that power setting, which when corrected to standard day condition, corresponds to a specified percentage of rated power. Without satisfactory correction factors, engines can be tested for compliance to emission limits only on natural or controlled standard days.

The EPA, in recognizing these present deficiencies, is requesting data on different classes of engines operated at various ambient conditions and proposing to develop correction routines that would standardize the emission values. The test discussed herein is intended to contribute to a comprehensive data bank and the development of these correction factors by supplying the EPA with data from a class T_1 engine.

5.2 PROGRAM APPROACH

An ALF 502 combustor was tested in the component test facilities at Avco Lycoming at various controlled inlet conditions and engine level confirmation tests were run on a full turbofan configuration.

The required emissions data were obtained by using two of Lycoming's modern data systems; one is specifically engineered for accurate measurement of gaseous emissions from engines and combustor rigs, and the second for measurement of particulate emissions (smoke). Both combustor rig tests and full engine verification tests on the ALF 502 fan engine were run over a number of equivalent ambient and power conditions to provide a data matrix from which correlation factors may be obtained.

Sampling of the exhaust constituents for the rig and engine test was accomplished by a probe-averaging technique. The combustor rig gas sampling probe comprised an eight-leg, five-hole per leg (40 total) arrangement for a representative average of the circumferential and radial distributions typical at the combustor exit plane. The engine probe was of the standard cruciform averaging configuration with three holes per leg (12 total) sized and radially spaced as in the rig probe. This arrangement is sufficient for representative samples in the engine exhaust because of the mixing effect of the turbine section. This has been confirmed by the close correlation between calculated and measured fuel-air ratios in this program and previous testing.

The exhaust constituents measured were CO, CO_2, NO, NO_x, and unburned hydrocarbons (UHC). These emissions were measured using Lycoming's DS 18 data system. This system designed and built to meet the EPA system requirements incorporates the latest equipment and operation techniques.

All measurements using this system were made using the techniques described in Part 87, Title 40, published in the Federal Register, Volume 38, No. 136, July 1973, with exceptions notes in Appendix A.

The smoke system, DS16C, was used in conjunction with the DS18 gas analysis system to sample the particulate content of the combustor rig and engine exhaust.

The sample to the smoke system was obtained from the same probes and extracted upstream of the DS18 system by means of a selector valve. The smoke system then operates independently and obtains samples at the required flow rates. All procedures are in accordance with paragraph 87. 85 of the Federal Register, Part 87.

The combustor and engine operating conditions were selected to meet the seven equivalent power points stated in the RFQ, i. e., (taxi) idle, 1. 5 times idle power, climbout, approach, takeoff, and cruise. Idle power and cruise conditions were selected based on a typical airframe installation and power turbine configuration, while takeoff, climbout, and approach points were based on maximum engine turbine inlet temperature and powers as stated in the model specifications.

The combustor test rig was to have been operated at the seven simulated engine power conditions for each of the environmental conditions specified in Table 2-2. However, difficulties in achieving the higher power conditions limited the rig program to the three lower power settings: idle, 1. 5 times idle, and approach.

6.0 ENGINE DESCRIPTION

6.1 GENERAL

The ALF 502 is a 6500 lb thrust twin-spool turbofan engine (Figure 6-1) with a 6:1 bypass ratio selected for improved cruise and loiter fuel consumption, as well as increased single-engine takeoff capability. The core engine derives from the Lycoming T55 series engine which has over three million hours of service experience. Accessories, including a completely self-contained oil system, are externally mounted on the fan module for maintainability, cool environment, and reduction of fire hazard.

The engine weighs 564 Kg (1245 lb) and has a basic diameter of 1.077 meters (42.4 inches) and overall length of 1.56 meters (61.43 inches), including spinner.

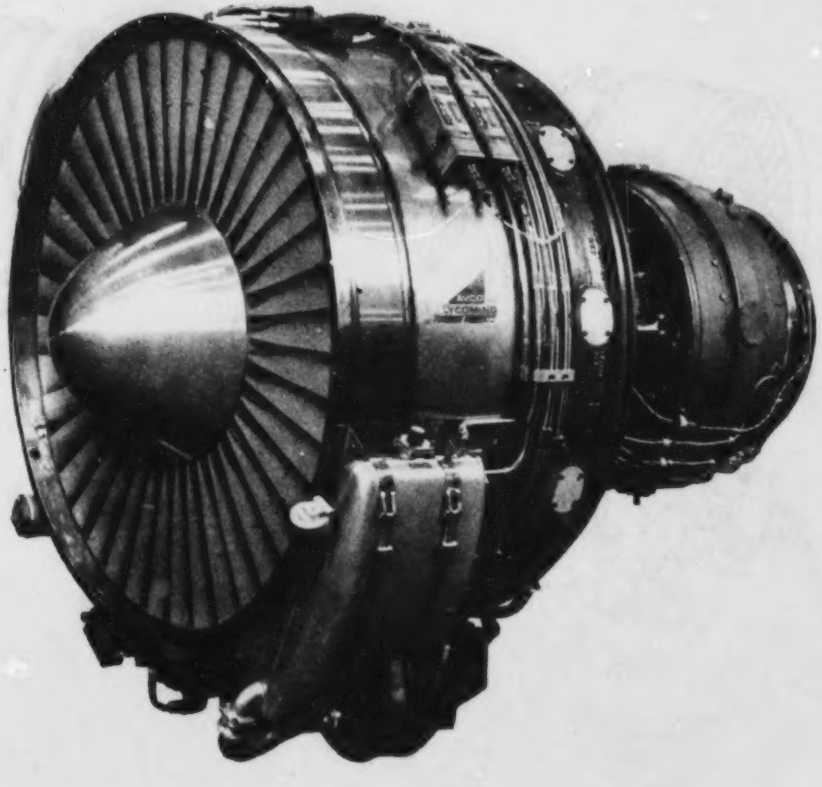


Figure 6-1. Turbofan Engine (Typical)

The low-pressure spool incorporates a single-stage fan that provides both the bypass efflux and airflow to the power producer. The air directed to the core engine is further compressed in the low-pressure spool by a single-stage supercharger. The low-pressure rotor is driven by a two-stage uncooled turbine through a single planetary reduction gear within the fan module. The high-pressure components of the engine include an axial/centrifugal compressor, a folded annular atomizing combustor, and a two-stage turbine to drive the compressor. The four basic modules are shown in Figure 6-2.

The two components that have a major effect on the engine's emissions profile, the combustor and fuel control, are described in this section.

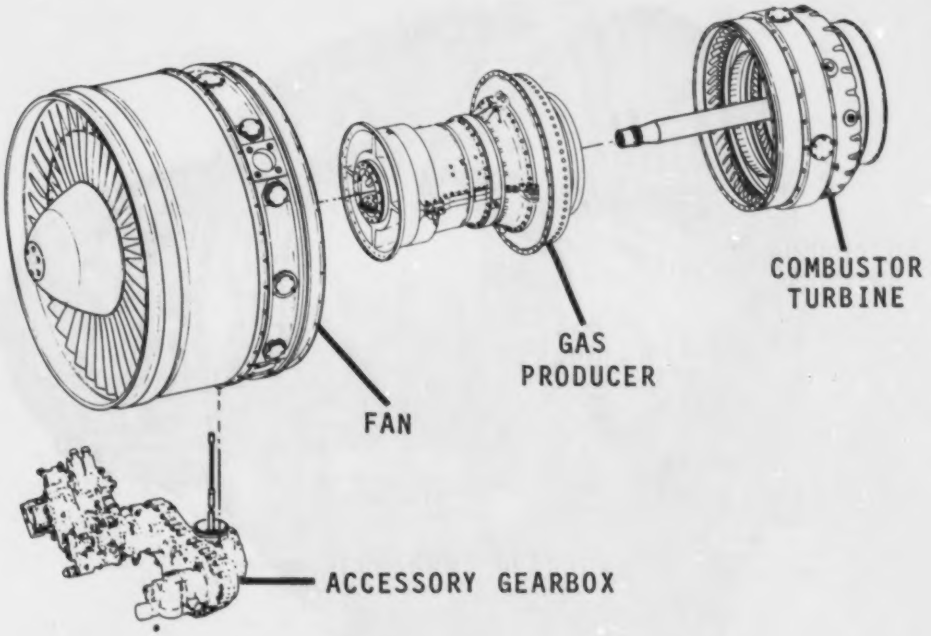


Figure 6-2. Engine Modules.

6.2 COMBUSTION SYSTEM

6.2.1 Description

The combustion system for the ALF-502 consists of a reverse-flow annular combustor with an air blast atomizing fuel injection system. This folded design permits maximum use of space and reduces engine length.

6.2.2 Combustor

The combustor includes a vortex-stabilized primary zone. The stabilizing vortices are formed by the air discharging from 28 cast radial inflow swirlers which have a fuel atomizer at each of their centers. Holes are placed in the liner sides at each swirler location to provide aerodynamic blockage and contain the toroid formed by the vortex in the primary zone.

In the intermediate zone, air is introduced to complete combustion and initiate dilution. This is done by means of sets of holes on the outer and inner liners.

The dilution zone includes additional holes distributed to meet radial circumferential temperature distribution requirements of the turbine.

Cooling of the liner walls is achieved by introducing a metered film of air and ensuring that it remains close to the walls.

The combustion products discharge into a curl that reverses the direction of flow to feed the turbine.

6.2.3 Fuel Injection System

The fuel injection system uses 28 air blast, main fuel injector nozzles with coaxial pressure atomizing pilot nozzles used primarily for engine light-off. The nozzles screw into a two-piece main fuel manifold having two separate internal passages.

A flow divider meters fuel to these nozzles in accordance with predetermined schedule of air blase versus pilot fuel flow, i.e., fuel passes through the flow divider and out to the pilot manifolds. The pressure drop across the flow divider creates a force that displaces a plunger that progressively opens the main flow metering ports and allows fuel to pass to the air blast fuel manifolds as engine fuel flow increases.

6.3 FUEL AND POWER CONTROL SYSTEM

6.3.1 General

The ALF 502 power control system (Figure 6-3) consists of three major subsystems:

- A gas producer fuel and power control
- An interstage air-bleed control system, and
- An inlet guide vane control system.

The fuel control is a hydromechanical type consisting essentially of the following main elements:

1. Fuel pump
2. Gas producer speed governor
3. Acceleration and deceleration control
4. Maximum fuel flow limiter
5. Main power lever and fuel shutoff valve
6. Compressor interstage air-bleed control
7. Inlet guide vane control.

The air-bleed and guide vane controls are actuated through fuel control signals to the respective actuators.

6.3.2 Gas Producer and Power Control System

The gas producer fuel and power control, with an integral fuel pump, is mounted directly to the accessory gearbox.

A gas producer speed governor regulates gas producer rotor speed to the value selected by the power lever over the range from ground idle to take-off thrust. Screw-type adjustments are provided to allow maximum and ground idle steady-state speed settings to be adjusted.

Acceleration fuel flow limits are scheduled over the entire operating range from starting to maximum gas producer speed by scheduling maximum fuel flow as a function of gas producer rotor speed, compressor discharge pressure, and fan inlet temperature. A deceleration schedule is provided to prevent engine flameout during deceleration. The absolute minimum fuel flow for deceleration or steady-state operation is determined by a minimum fuel flow stop that limits the closing of the main metering valve.

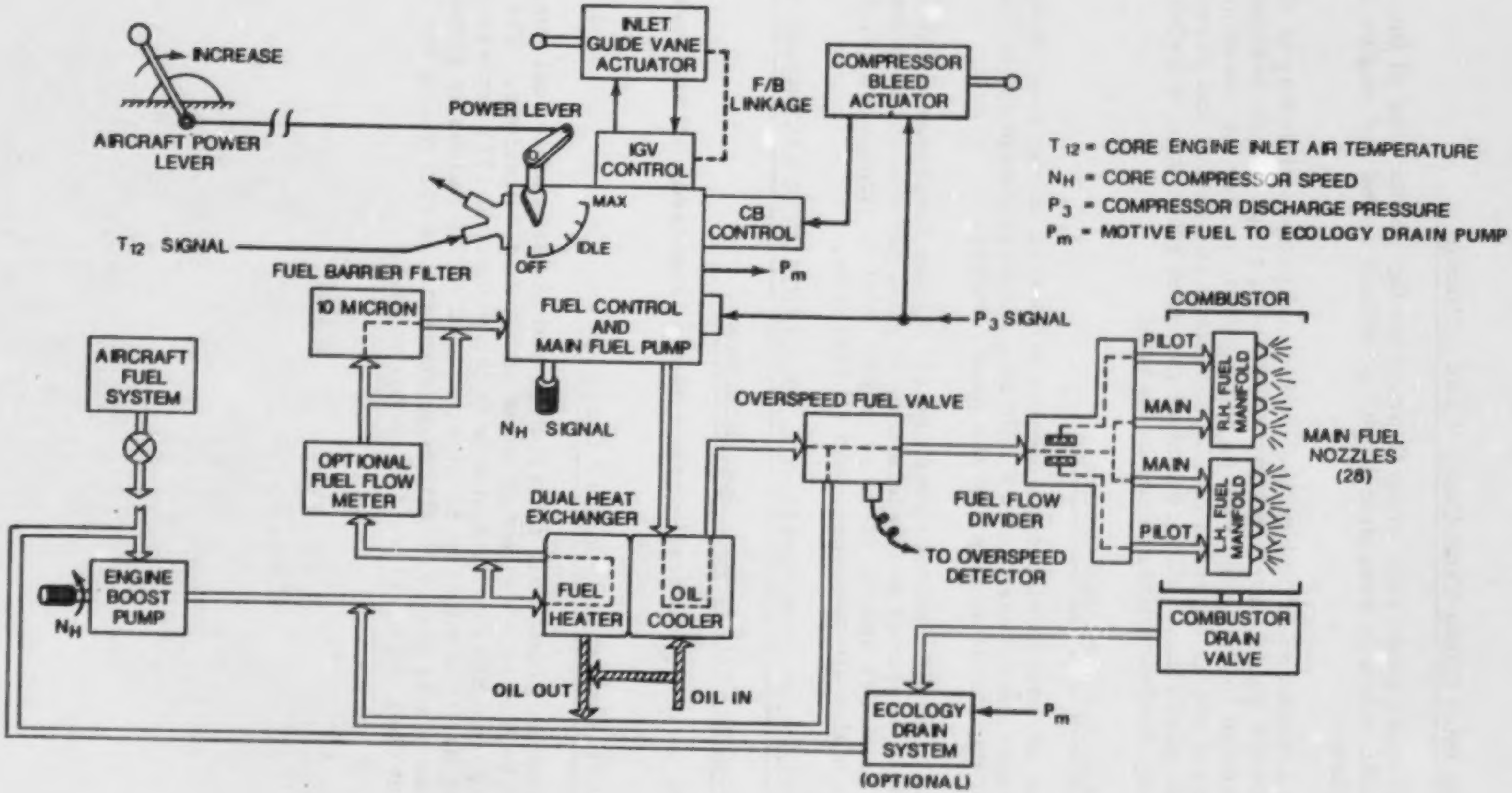

INCREASE
AIRCRAFT POWER LEVER
POWER LEVER
INLET GUIDE VANE ACTUATOR
F/B LINKAGE
COMPRESSOR BLEED ACTUATOR
IGV CONTROL
CB CONTROL
MAX
IDLE
OFF
T_{12} SIGNAL
FUEL BARRIER FILTER
10 MICRON
FUEL CONTROL AND MAIN FUEL PUMP
P_m
P_3 SIGNAL
N_H SIGNAL
AIRCRAFT FUEL SYSTEM
OPTIONAL FUEL FLOW METER
DUAL HEAT EXCHANGER
FUEL HEATER
OIL COOLER
OIL OUT
OIL IN
ENGINE BOOST PUMP
N_H
OVERSPEED FUEL VALVE
TO OVERSPEED DETECTOR
FUEL FLOW DIVIDER
COMBUSTOR
PILOT
MAIN
MAIN
PILOT
R.H. FUEL MANIFOLD
L.H. FUEL MANIFOLD
MAIN FUEL NOZZLES (28)
COMBUSTOR DRAIN VALVE
ECOLOGY DRAIN SYSTEM (OPTIONAL)
P_m
T_{12} = CORE ENGINE INLET AIR TEMPERATURE
N_H = CORE COMPRESSOR SPEED
P_3 = COMPRESSOR DISCHARGE PRESSURE
P_m = MOTIVE FUEL TO ECOLOGY DRAIN PUMP

Figure 6-3. Power Control and Fuel System Schematic.

6.3.3 Variable Inlet Guide Vane Control and Actuator

The inlet guide vane control provides for positioning of the compressor inlet guide vanes in response to gas producer speed and engine inlet temperature.

An actuator mounted on the engine compressor housing is directly linked to the guide vanes by a synchronizing ring. While making the desired motion to the guide vanes, the actuator relays its position back to the control via an external feedback linkage to restore the servo valve to a null position. Adjustment of the inlet guide vane schedule is made within the feedback linkage on the engine.

6.3.4 Interstage Airbleed and Control

The interstage airbleed actuator is located on the rear flange of the core engine compressor. A single line delivers compressor discharge air for both the signal source and the power supply.

The airbleed control opens and closes the compressor interstage airbleed in response to the following signals present in the power control: (1) gas producer speed, (2) core engine inlet air temperature, (3) compressor outlet air pressure, and (4) fuel flow.

6.4 GENERAL PERFORMANCE SPECIFICATION AND EPAP VALUES DATA

6.4.1 Engine Performance Specifications

General engine performance data at standard-day sea level conditions given in Table 6-1.

6.4.2 1979 Emissions Standard Comparison

The combustor air distribution and airblast style fuel nozzles used in the ALF 502 engine provide low gaseous and smoke emissions. The present configuration approaches conformance with the projected 1979 emission limits for a T-1 class engine. A summary of the computed EPAP values is given in Table 6-2. The engine meets the 1979 NO_x requirements, barely meets the UHC requirements, but does not meet the CO requirements.

TABLE 6-1. GUARANTEED PERFORMANCE AT SEA LEVEL STATIC STANDARD DAY ATMOSPHERIC CONDITIONS (ALF 502D AND 502H ENGINES)

RATING	TOTAL NET THRUST (Minimum) (lb)	GAS GENERATOR ROTOR SPEED (Maximum) (rpm)	FAN ROTOR SPEED (Maximum) (rpm)	THRUST SPECIFIC FUEL CONSUMPTION (Maximum) (lb/hr/lb)	TOTAL AIRFLOW (lb/sec) ± 5%
Takeoff	6,500	19,639	7,121	0.417	235.7
Maximum Climb	6,170	19,413	6,988	0.412	235.7
Maximum Cruise	5,675	19,073	6,780	0.406	228.3
Flight Idle	743 (Max)	13,720	2,890	458 lb/hr	86.8
Ground Idle	400 (Max)	10,300	1,865	350 lb/hr	62.5

NOTES:

1. The guaranteed performance values are consistent with the conditions specified in Model Specification with tailpipe and fan duct as shown in applicable figures and all losses associated therewith.

2. The above data is based on operation with no loading of accessory drives, zero customer bleed, and 100 percent inlet ram recovery.

TABLE 6-2. ENGINE EPAP CALCULATION AND COMPARISON WITH EPA 1979 REQUIREMENTS

ENGINE MODEL: ALF 502D , LF 02 T-1
COMBUSTOR S/V: 11.76 ft^{-1}
CLASS: T-1
VOLUME:

CONFIGURATION: -46 Cert. Config.

MAXIMUM POWER: 6500 lb/thrust
IDLE POWER: 400 lb/thrust
DATA SOURCE: EPA Test, August, 1976

MODE	P_3 Atm	T_3 °R	W_{ab} lb/sec	W_f lb/hr	W_f/W_{ab}	$W_f/W_{aex.}$		θ			UHC gm/kg	CO gm/kg	NO_x gm/kg	Smoke No.	η_b %
IDLE	2.25	715	7.9	370	.0130	.011		1.49			5.6	40.7	2.91	3	98.55
APPROACH	5.0	898	17.5	778	.0123	.0109		3.88			.57	11.0	5.88	9	99.68
CLIMBOUT	10.2	1120	30.0	2340	.0217	.0191		11.9			.11	0.5	9.37	25	99.99
TAKEOFF	11.1	1150	31.7	2650	.0232	.0205		13.7			.11	0.5	10.10	25	99.99
EPAP (from test results)											1.53	11.71	3.15		
EPAP (EPA 1979 requirements)											1.60	9.40	3.70		

Unless noted, fuel is Jet A, UHC = CH_4, NO_x = NO_2 All Values Referred to ISO Standard Day

CO - Carbon Monoxide
NO_x - Oxides of Nitrogren
UHC - Unburned Hydrocarbons
P_3 - Combustor Inlet Pressure
T_3 - Combustor Inlet Temperature
W_{ab} - Combustor Acutal Air Flow
W_f - Fuel Flow
W_f/W_{ab} - Combustor Fuel-Air Ratio
$W_f/W_{aex.}$ - Exhaust Fuel-Air Ratio

η_b - Combustor Efficiency
S/V - Surface Area/Volume
θ - Theta Correlation Parameter = $(P_3^{1.75}/Wa)*$
Exp $(T_3/534.3)$ $AD^{.75}$

Where
A = Area
b = $\sqrt{4A/\pi}$

7.0 TEST-POINT SELECTION

7.1 ENGINE TEST

The ALF 502 turbofan engine has a standard-day rating of 6500 pounds thrust. At ambient conditions other than a standard-day, thrust and turbine temperature limitations are placed on engine operation to maintain the mechanical integrity of the components.

During actual aircraft operation except at idle, the exhaust gas temperature (T4.1) and fan rotor speed, N_{II}, are maintained within the specification limits of the particular engine. A constant maximum N_{II} directly relates to a constant maximum thrust, therefore, at temperatures below 15°C (59°F), while the EGT limit will not be reached, the thrust is not to exceed the 6500-pound rating.

The turbine hardware operating temperature limits require that the maximum EGT specified with the engine not be exceeded during operation. As the inlet temperature increases above 15°C, the maximum thrust is reduced proportionally to maintain a tolerable condition in the hot section. During this test program, the ambient temperature was greater than 15°C, thus EGT and not thrust was the limiting parameter.

The EGT/thrust characteristic of the engine was defined prior to the emission program by an engine calibration to determine the thrust-temperature characteristic. The idle and 1 1/2 idle performance was checked at a constant 400-pound and 600-pound thrust to be consistent with aircraft operation.

Two calibration runs were performed, one with and one without the gas emission probe in place at the tailpipe exhaust. The effect of the probe could then be determined and compensations made, if necessary.

The data from the $T_{4.1}$ harness, consisting of eight thermocouples at the power turbine inlet, was obtained for each of the power conditions. A correction of the temperature data to standard day condition was made for each value by $\theta^{1.022}$ (θ = Tamb/518.688). This correction factor, in lieu of the standard differential parameter ($\theta^{1.0}$), was developed for a range of ambient temperatures using an engine simulation program that accounts for changes in the air and gas properties, the engine rematch caused by the air and gas property changes, and the component performance changes caused by the rematch. The resulting values were then plotted (Figure 7-1) against referred thrust (F_N/δ). The probe effect was small but noticeable at the higher thrust levels. The thrust levels to be investigated were idle (400 lb), 1-1/2 idle (600 lb), approach (1950 lb), cruise 1 (2900 lb), cruise 2 (3200 lb), climbout (5850 lb), and takeoff (6500 lb). The two cruise conditions were to cover the range of the expected maximum power condition that could be duplicated during the combustor rig test.

From Figure 7-1, gas temperatures for approach through takeoff were obtained. The engine power setting was to be adjusted to achieve these values regardless of inlet temperature conditions for each day's emission test.

7.2 COMBUSTOR RIG TEST

The combustor rig test conditions were selected, where possible, to duplicate the combustor environment present in the engine. Considerations for the rig test facility limitations and local weather conditions were required in the selection of the test points simulating the higher power settings.

The idle, 1 1/2 idle, approach, and 2900-lb thrust conditions were within the capabilities of the system. Both 2900-pound and 3200-pound thrust points were chosen for the engine test (completed first) to allow possible rig operation at the higher level if the facility limits could be satisfactorily extended.

Based on past humidity information recorded by the National Weather Service, 25 grains were selected as the minimum condition consistently achieveable for the test since no air drying capability was available. Also, the ambient temperature and barometer were considered in the point selection.

The facility cooling and heating capacity limited the high-flow cold-day simulations on warmer ambient days and warm humid-day simulation on cold dry days. The additional heat capacity required to evaporate large quantities of water injected into the system for humidification required consideration in the selection process.

An engine simulation computer program was used to generate the combustor parameters for a typical engine operating on a standard day at selected power levels. This program uses component performance data and a matching technique to develop the values of interest.

The core compressor airflow at each power condition was adjusted to compensate for the turbine cooling air extraction and interstage bleed air at the idle and 1 1/2 idle points. The nominal turbine cooling airflow of 11 percent was to be used in computing the rig combustor airflow, and a nominal value of 13 percent was applied to the airflow data for compressor bleed.

The standard-day pressures, temperatures, and air and fuel flows were adjusted to each of the ambient conditions to be simulated. The referral factors used are defined in Table 7-1, and tabulation of the data points and resulting conditions to be investigated are shown in Table 7-2.

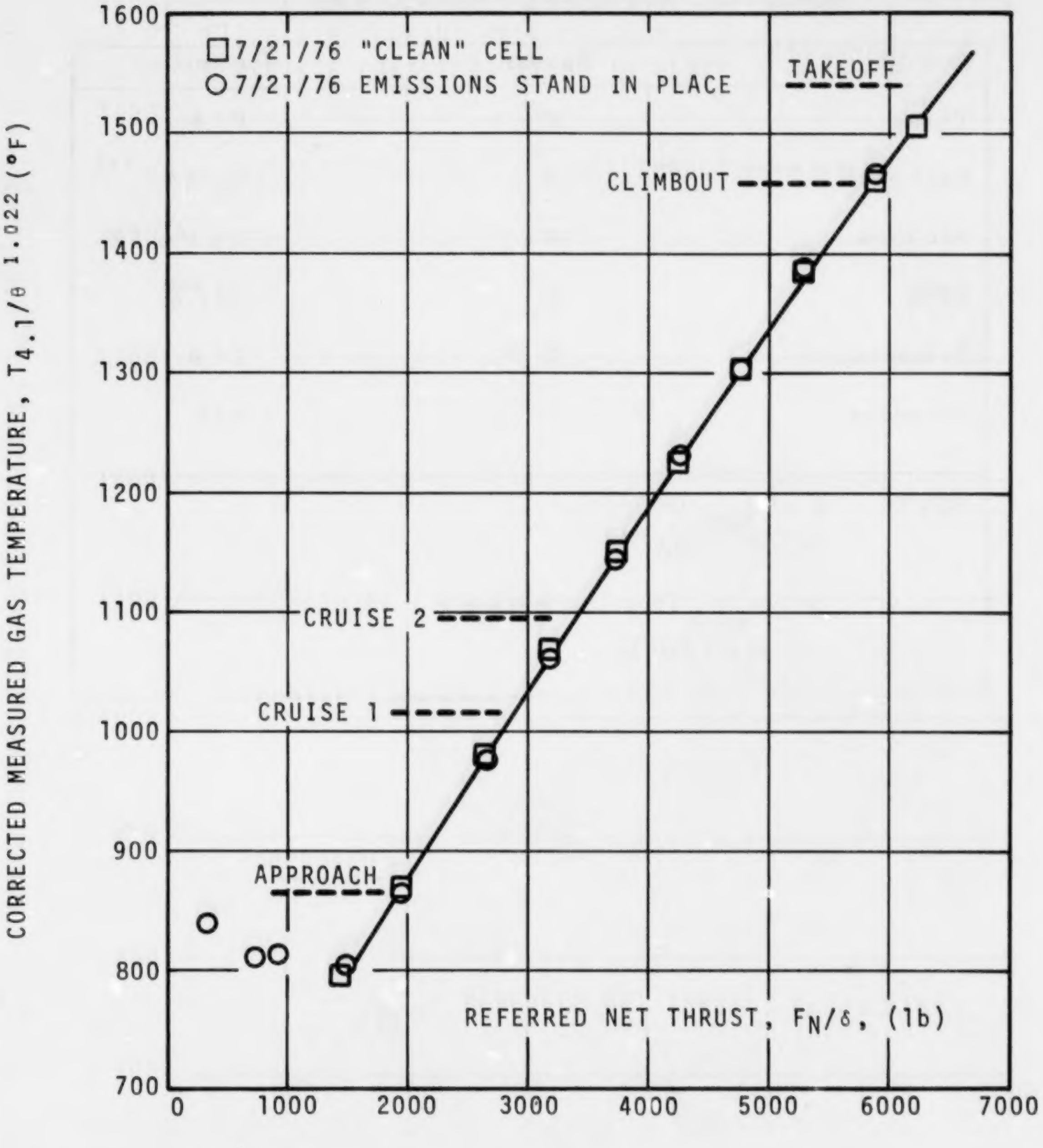


Figure 7-1. ALF 502 Corrected Measured Gas Temperature Versus Referred Net Thrust.

TABLE 7-1. REFERRAL PARAMETERS

Quantity	Symbol	Parameter
Thrust	F	F/δ
Fuel Flow	W_f	$W_f/\delta\,\theta^{.712}$
Air Flow	Wa	$Wa\sqrt{\theta}/\delta$
RPM	M	$N/\sqrt{\theta}$
Temperature	T	T/θ
Pressure	P	P/δ

NOTE:

$$\delta = \frac{P_{AMB}\ (\text{PSIA})}{14.696\ (\text{PSIA})}$$

$$\theta = \frac{T_{AMB}\ ({}^{o}R)}{518.688({}^{o}R)}$$

TABLE 7-2. COMBUSTOR RIG TEST CONDITIONS

DATA Pt No.	TO (°R)	PO (in Hg)	T3 (°F)	P3 (psia)	Wa (pps)	GR. H_2O/ LB AIR	W_f (pph)	A/F	EQUIV. THRUST (lb)
001145	519	29.92	225	35	7.25	44	350	74.6	400
002145	519	29.92	285	40	10.5	44	420	90	600
003144	519	29.92	440	75	17.8	44	790	81.1	1950
0041x4	519	29.92	502	96	21.0	44	1130	66.9	2900
0071x4	519	29.92	424	96	21.0	44	1680	45	5850
0081x4	519	29.92	414	96	21.0	44	1802	42	6500
191135	479	25.98	173	30.4	6.55	25	287	82.2	400
011135	479	29.92	173	35	7.55	25	331	82.2	400
151135	479	32.28	173	37.8	8.14	25	357	82.2	400
021135	499	29.92	199	35	7.39	25	340	78.2	400
061135	499	29.92	199	35	739	35	340	78.2	400
201145	519	25.98	225	30.4	6.29	52.5	304	74.6	400
031135	519	29.92	225	35	7.25	25	350	74.6	400
071145	519	29.92	225	35	7.25	52.5	350	74.6	400
1011x4	519	29.92	225	35	7.25	70.	350	74.6	400
161145	519	32.28	225	37.8	7.82	52.5	378	74.6	400
192135	479	25.98	228	34.7	9.5	25	344	99.2	600
012135	479	29.92	228	40	10.93	25	397	99.2	600
152135	479	32.28	228	43.2	11.79	25	428	99.2	600
022135	499	29.92	257	40	10.71	25	408	94.4	600
062145	499	29.92	257	40	10.71	35	408	94.4	600
041135	545	29.92	260	35	7.07	25	362	70.3	400
081145	545	29.92	260	35	7.07	52.2	362	70.3	400
111145	545	29.92	260	35	7.07	105	362	70.3	400
131145	545	29.92	260	35	7.07	175	362	70.3	400
202145	519	25.98	285	34.7	9.12	52.5	364	90	600
032135	519	29.92	285	40	10.5	25	420	90	600
072145	519	29.92	285	40	10.5	52.5	420	90	600
102145	519	29.92	285	40	10.5	70	420	90	600
162145	519	32.28	285	43.2	11.33	52.5	453	90.	600
211135	565	25.98	286	30.4	6.03	25	323	67.3	400
221145	565	25.98	286	30.4	6.03	175	323	67.3	400
051135	565	29.92	286	35	6.95	25	372	67.3	400
091145	565	29.92	286	35	6.95	52.5	372	67.3	400
121145	565	29.92	286	35	6.95	105	372	67.3	400
141145	565	29.92	286	35	6.95	175	372	67.3	400
171135	565	32.28	286	37.8	7.5	25	401	67.3	400
181145	565	32.28	286	37.8	7.5	175	401	67.3	400
042135	545	29.92	323	40	10.24	25	435	84.8	600

TABLE 7-2. COMBUSTOR RIG TEST CONDITIONS (Cont'd)

DATA Pt No.	TΘ (^oR)	PO (in Hg)	T3 (^oF)	P3 (psia)	Wa (pps)	GR. H_2O/ LB AIR	W_f (pph)	A/F	EQUIV. THRUST (lb)
082145	545	29.92	323	40	10.24	52.5	435	84.8	600
112145	545	29.92	323	40	10.24	105	435	84.8	600
132145	545	29.92	323	40	10.24	175	435	84.8	600
212135	565	25.98	351	34.7	8.74	25	387	81.2	600
222145	565	25.98	351	34.7	8.74	175	387	81.2	600
052135	565	29.92	351	40	10.1	25	446	81.2	600
092145	565	29.92	351	40	10.1	52.5	446	81.2	600
122145	565	29,92	351	40	10.1	105	446	81.2	600
142145	565	29.92	351	40	10.1	175	446	81.2	600
172135	565	32.28	351	43.2	10.9	25	482	81.2	600
182155	565	32.28	351	43.2	10.9	175	482	81.2	600
1981x4	479	25.98	345	83.4	19.0	25	1478	46.2	6500
0181x4	479	29.92	345.	96	21.85	25	1701	46.2	6500
1581x4	479	32.28	345	103.6	23.58	25	1835	46.2	6500
193134	479	25.98	371	65.1	16.1	25	648	89.4	1950
013144	479	29.92	371	75	18.53	25	746	89.4	1950
153144	479	32.28	371	80.9	20.0	25	805	89.4	1950
0281x4	499	29.92	380	96.	21.42	25	1753	44.	6500
0681x4	499	29.92	380	96.	21.42	35	1753	44.	6500
023134	499	29.92	405	75.	18.2	25	768	85.1	1950
063144	499	29.92	405	75.	18.2	35	768	85.1	1950
2081x4	519	25.98	414	83.4	18.23	52.5	1564	42.	6500
0381x4	519	29.92	414	96	21.	25	1802	42.	6500
0781x4	519	29.92	414	96	21.	52.5	1802	42.	6500
1081x4	519	29.92	414	96	21.	70	1802	42.	6500
1681x4	519	32.28	414	103.6	22.6	52.5	1945	42.	6500
1941x4	479	25.98	428	83.4	19.0	25	927	73.7	2900
0141x4	479	29.92	428	96	21.85	25	1067	73.7	2900
1541x4	479	32.28	428	103.6	23.58	25	1151	73.7	2900
203144	519	25.98	440	65.1	15.46	52.5	686	81.1	1950

TABLE 7-2. COMBUSTOR RIG TEST CONDITIONS (Cont'd)

DATA Pt No.	TO (°R)	PO (in Hg)	T3 (°F)	P3 (psia)	Wa (pps)	GR. H_2O/ LB AIR	W_f (pph)	A/F	EQUIV. THRUST (lb)
033134	519	29.92	440	75	17.8	25	790	81.1	1950
073144	519	29.92	440	75	17.8	52.5	790	81.1	1950
103144	519	29.92	440	75	17.8	70	790	81.1	1950
163144	519	32.28	440	80.9	19.2	52.5	852	81.1	1950
0461x4	545	29.92	464	96	20.5	25	1734	42.6	5780
0861x4	545	29.92	464	96	20.5	52.5	1734	42.6	5780
1161x4	545	29.92	464	96	20.5	105	1734	42.6	5780
1361x4	545	29.92	464	96	20.5	175	1734	42.6	5780
0241x4	499	29.92	465	96	21.42	25	1098	70.2	2900
0641x4	499	29.92	465	96	21.42	35	1098	70.2	2900
0431x4	545	29.92	485	75	17.36	25	818	76.4	1950
083134	545	29.92	485	75	17.36	52.5	818	76.4	1950
113144	545	29.92	485	75	17.36	105	818	76.4	1950
133154	545	29.92	485	75	17.36	175	818	76.4	1950
2151x4	565	25.98	495	83.4	17.47	25	1463	43.	5285
2251x4	565	25.98	495	88.4	17.47	175	1463	43	5285
0551x4	565	29.92	495	96	20.13	25	1686	43.	5285
0951x4	565	29.92	495	96	20.13	52.5	1686	43.	5285
1251x4	565	29.92	495	96	20.12	105	1686	43.	5285
1451x4	565	29.92	495	96	20.13	175	1686	43	5285
1751x4	565	32.28	495	103.6	21.7	25	1818	43	5285
1851x4	565	32.28	495	103.6	21.7	175	1818	43.	5285
2041x4	519	25.98	502	83.4	18.23	52.5	981	66.9	2900
0341x4	519	29.92	502	96	21.	25	1130	66.9	2900
0741x4	519	29.92	502.	96	21.	52.5	1130.	66.9	2900
104134	519	29.92	502.	96	21.	70	1130	66.9	2900
1641x4	519	32.28	502	103.6	22.6	52.5	1219	66.9	2900
2131x4	565	25.98	520	65.1	14.8	25	729	73.2	1950
223154	565	25.98	520	65.1	14.8	175	729	73.2	1950
0531x4	565	29.92	520	75	17.1	25	839	73.2	1950
093134	565	29.92	520	75	17.1	52.5	839	73.2	1950
123144	565	29.92	520	75	17.1	105	839	73.2	1950
143154	565	29.92	520	75	17.1	175	839	73.2	1950
1731x4	565	32.28	520	80.9	18.4	25	906	73.2	1950
183154	565	32.28	520	80.9	18.4	175	906	73.2	1950
0441x4	545	29.92	550	96	20.5	25	1170	63.1	2900
0841x4	545	29.92	550	96	20.5	52.2	1170	63.1	2900
114144	545	29.92	550	96	20.5	105	1170	63.1	2900

TABLE 7-2. COMBUSTOR RIG TEST CONDITIONS (Cont'd)

DATA Pt No.	TO (^oR)	PO (in Hg)	T3 (^oF)	P3 (psia)	Wa (pps)	GR. H_2O/ LB AIR	W_f (pph)	A/F	EQUIV. THRUST (lb)
1341x4	545	29.92	550	96	20.5	175	1170	63.1	2900
2141x4	565	25.98	587	83.4	17.47	25	1042	60.4	2900
2241x4	565	25.98	587	83.4	17.47	175	1042	60.4	2900
0541x4	565	29.92	587	96	20.13	25	1299	60.4	2900
0941x4	565	29.92	587	96	20.13	52.5	1200	60.4	2900
1241x4	565	29.92	587	96	20.13	105	1200	60.4	2900
1441x4	565	29.92	587	96	20.13	175	1200	60.4	2900
1741x4	565	32.28	587	103.6	21.7	25	1295	60.4	2900
1841x4	565	32.28	587	103.6	21.7	175	1295	60.4	2900

Data Point Number Code

Digits 1 & 2 - Test Condition (Ref Table 2-3)

Digits 3 & 4 - Simulated Power Level

Digit 5 - Water Element, Lo=3, M=4, H=5 (Note X Indicates Point Not Run)

Digit 6 - Fuel Element (M=5 H=4)

NOTE: Due to extrapolation diffiluties in determining the low power air flows, the idle and 1.5 idle fuel-air ratios run during the combustor rig tests do not correspond to the actual engine conditions (rig idle was 11% to rich and rig 1.5 idle 11% to lean)

8.0 MEASUREMENT TECHNIQUES AND EQUIPMENT

8.1 GENERAL

The instrumentation techniques and data acquisition systems used for the emissions program were selected to assure that accurate quality measurements could be achieved in both the combustor rig and engine tests. The goals were twofold, i.e., one to measure the aerothermodynamic parameters and the second to determine the combustor emissions. Sensors to measure the desired temperatures, pressures, and flows and probes to extract samples for emissions and humidity measurements were specially designed for their location and application. Lycoming-designed automatic data recording and measuring systems were extensively used for data management. Final computation and compilation was accomplished at Lycoming's main computer center.

8.2 EMISSIONS MEASUREMENTS

Engine exhaust and combustor rig emissions were measured with equipment and procedures conforming to present EPA regulations as defined in Title 40, Part 87 of the Federal Register. The methods defined were expanded and modified slightly, primarily to encompass the combustor rig tests, as indicated in the correspondence included in Appendix A.

Different probe designs were used in the engine and rig tests because of the sampling plane locations and thermal conditions. The same Lycoming emission-measurement system was used in both tests to assure consistency of results.

8.3 ENGINE EMISSION SAMPLING PROBE

The engine exhaust emissions sampling probe (Figure 8-1) consists of two sets of four legs that are equally spaced circumferentially with three sample holes per leg. This probe assembly is made in conformance with Lycoming P/N TE28008 (Figure 8-2). During the test, only the forward set of legs was used for both smoke and gaseous emissions sampling.

Each of the three sample holes in each leg was 1.143 mm (0.045 inch) in diameter, giving a total area of 13.55 mm^2 (0.021 in.^{2}) for the twelve holes. These dimensions were chosen to be compatible with the system pumping capacity in achieving over 80 percent of the system pressure loss in the probe and to assure a large enough area to resist contaminant clogging. The holes in each leg were located at centers of equal geometric areas, a condition that Lycoming has found to give representative results within 10 percent as reported by Rubins

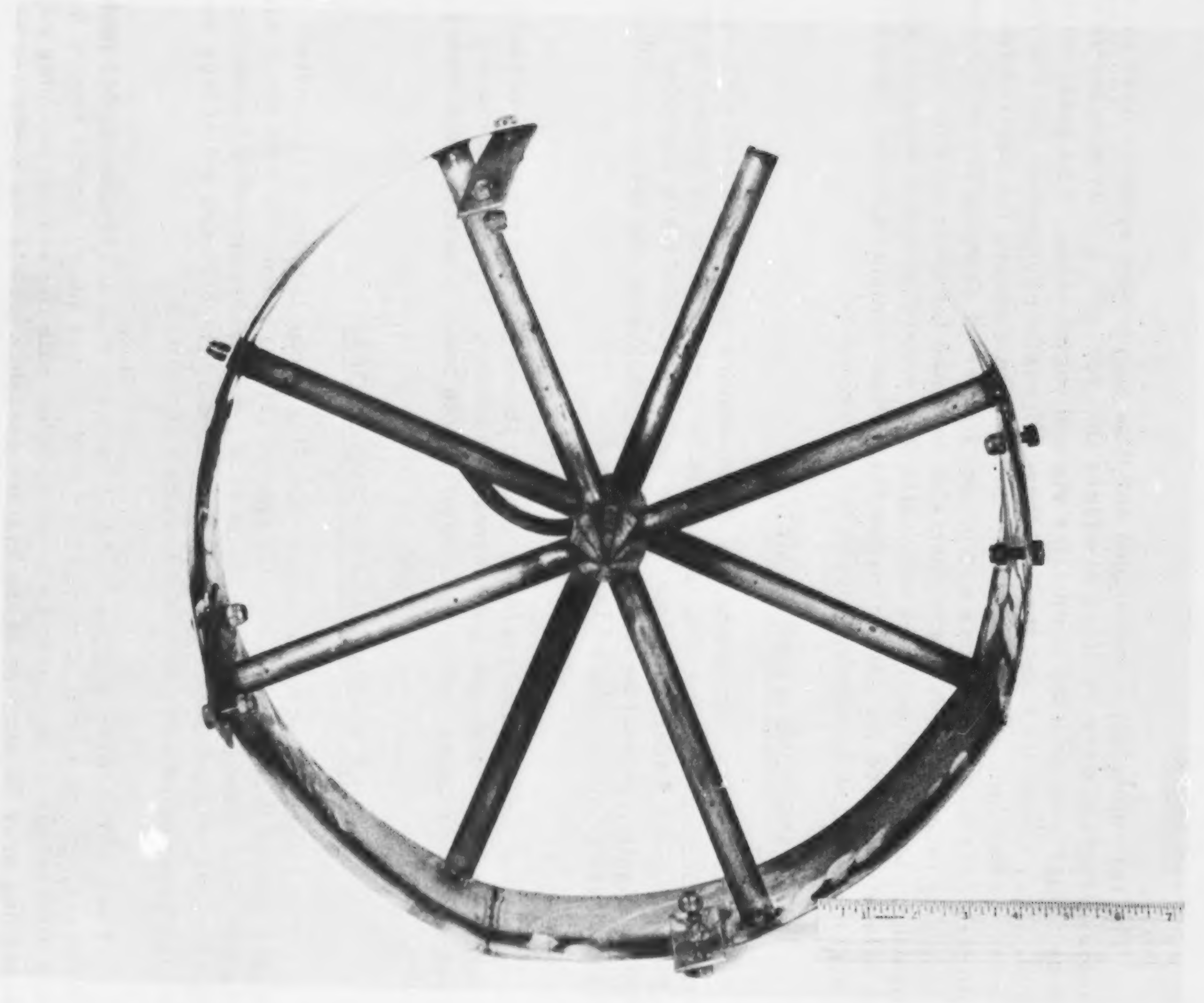
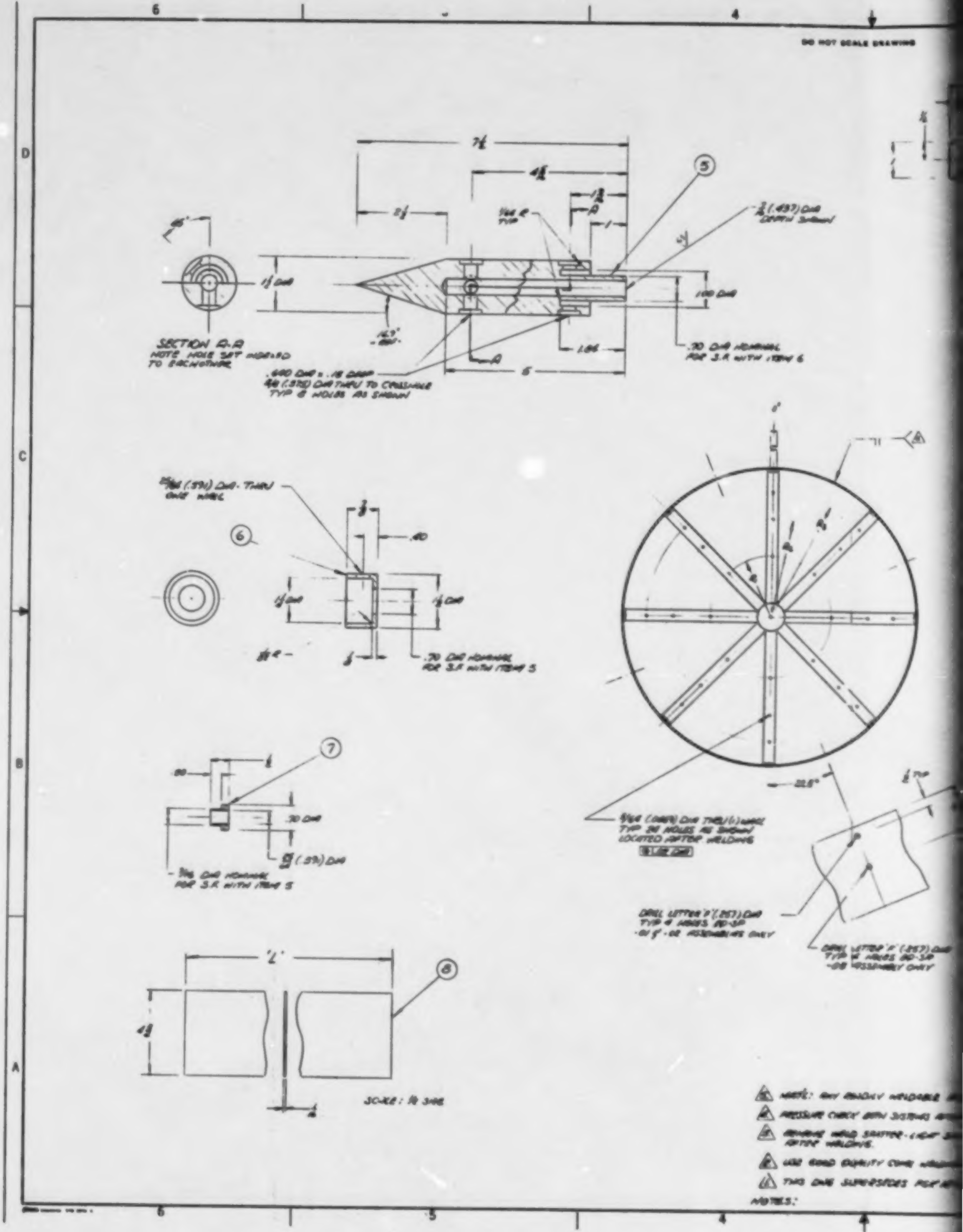
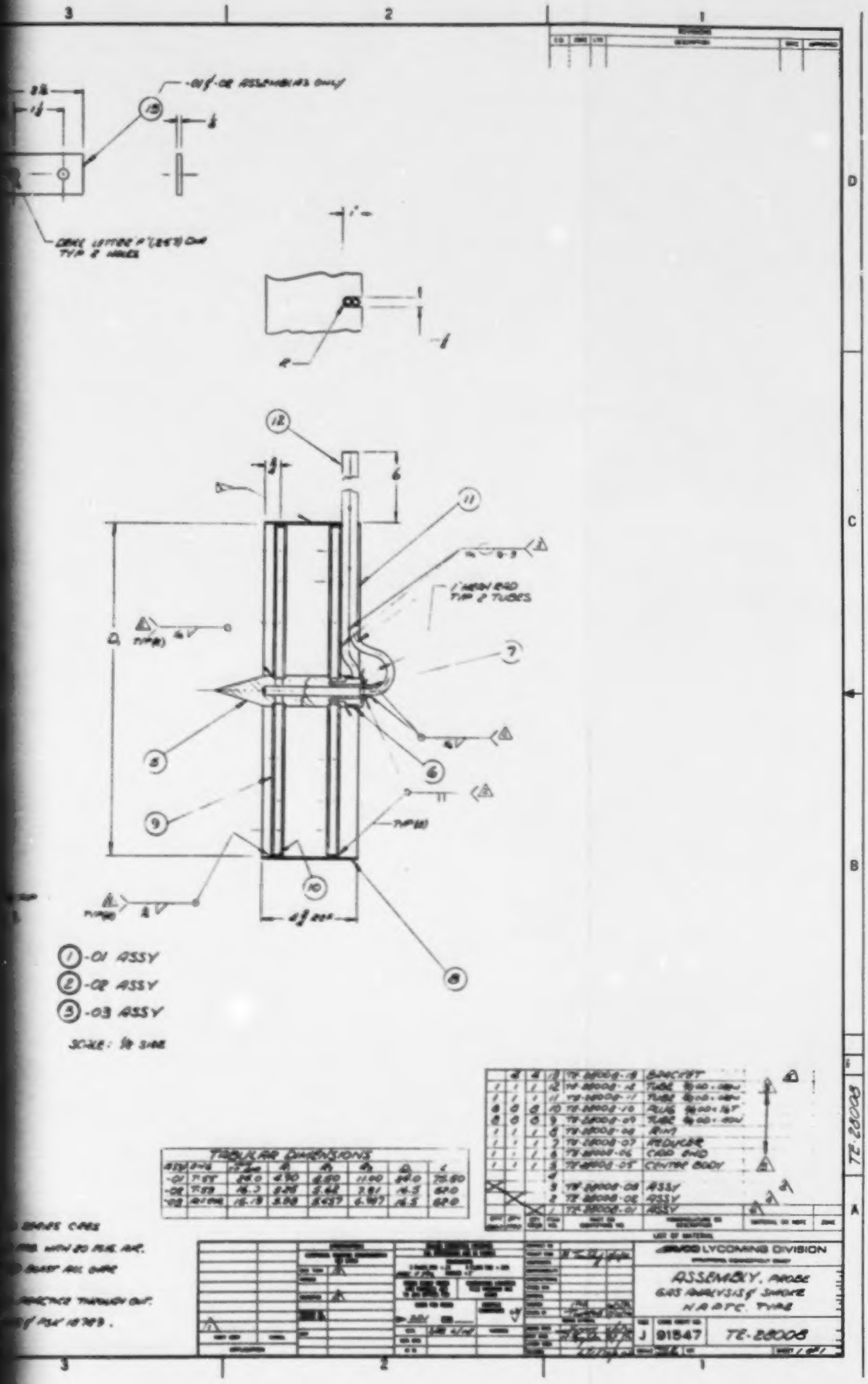


Figure 8-1. Engine Exhaust Averaging Gas Sample Probe.



DO NOT SCALE DRAWING
SECTION A-A
NOTE HOLE SET INDEXED TO EACHOTHER
.440 DIA x .18 DEEP
TYP 8 HOLES AS SHOWN
.100 DIA
.70 DIA NOMINAL FOR S.F. WITH ITEM 6
5
6
.70 DIA NOMINAL FOR S.F. WITH ITEM 5
7
8
SCALE: ½ SIZE
TYP 24 HOLES AS SHOWN
LOCATED AFTER WELDING
22.5°
NOTES:

Figure 8-2. Engine Gas Sample Probe Drawing - Lycoming P/N TE 28008.


-01 & -02 ASSEMBLIES ONLY
TYP 2 HOLES
1" MIN RAD TYP 2 TUBES
TYP(2)
①-01 ASSY
②-02 ASSY
③-03 ASSY
SCALE: 1/2 SIZE
TABULAR DIMENSIONS
-01 T-55 24.0 4.90 4.50 11.00 24.0 75.80
-02 T-53 16.3 2.25 5.62 2.81 14.5 62.0
-03 15.13 3.90 5.437 6.797 14.5 62.0
TE-28008-13 BRACKET
TE-28008-12 TUBE
TE-28008-11 TUBE
TE-28008-10 PLUG
TE-28008-09 TUBE
TE-28008-08 RIM
TE-28008-07 REDUCER
TE-28008-06 CLOSE END
TE-28008-05 CENTER BODY
TE-28008-03 ASSY
TE-28008-02 ASSY
TE-28008-01 ASSY
LIST OF MATERIAL
WITH 20 PSIG AIR.
PRACTICE THROUGHOUT.
LYCOMING DIVISION
ASSEMBLY, PROBE
GAS ANALYSIS & SMOKE
NAAPC TYPE
J 91547 TE-28008
TE-28008
D
C
B
A
3
2
1

β

and Doyle (1).

8.4 COMBUSTOR RIG EMISSION SAMPLING PROBE

The combustion rig emissions sampling probe assembly (Figure 8-3) consists of eight individual probes (Figure 8-4) manifolded to a central collection tube. The individual probes are liquid cooled to promote chemical-reaction quenching of the sample and to provide the required endurance life at combustor exit temperature levels. The individual probes are made in conformance with Lycoming P/N TE28010-01 (Figure 8-5).

The eight gas sample probes were mounted as an assembly in the test rig instrument drum at equally spaced increments in the plane of the first turbine nozzle inlet. Each probe consisted of five manifolded 0.483 mm (.019 inch)ports at centers of equal geometric areas and a cooling fluid inlet and outlet port. The probes were connected to a triple manifold system mounted to the instrument drum. The manifold provided the cooling fluid path to each of the probes and the return flow through a second path. The third manifold route was used for sample extraction.

The larger number of 40 sample holes in the rig, versus only 12 in the engine, has been found necessary to provide a representative sample at the combustor exit plane where conditions are less homogeneous.

8.5 GASEOUS EMISSIONS MEASUREMENT DATA SYSTEM DS18

The DS18 emission system is a portable unit used for engine and combustor tests to measure the various constituents of the exhaust, including hydrocarbons, carbon monoxide, carbon dioxide, and oxides of nitrogen. All instruments and sampling techniques are consistent with the procedures established by the Environmental Protection Agency and published in Title 40, Part 87 of the Federal Register.

The system is configured to three basic types of gas analyzing instruments. A flame ionization (FID)-type detector is used for total hydrocarbon (THC) content; chemiluminescence detection methods are used for oxides of nitrogen; and non-dispersive infrared detection (NDIR) is used for carbon monoxide and carbon dioxide.

8.5.1 Hydrocarbon Analyzer

The hydrocarbon analyzer is a Varian Aerograph™, model 1400 gas chromatograph with an FID detector. The operation of the of the instrument

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(1) T53 and T55 Gas Turbine Combustor and Engine Exhaust Emission Measurements by Philip Rubins and Brian W. Doyle, USAAMRDL Tech Report 73-47 December 1973.

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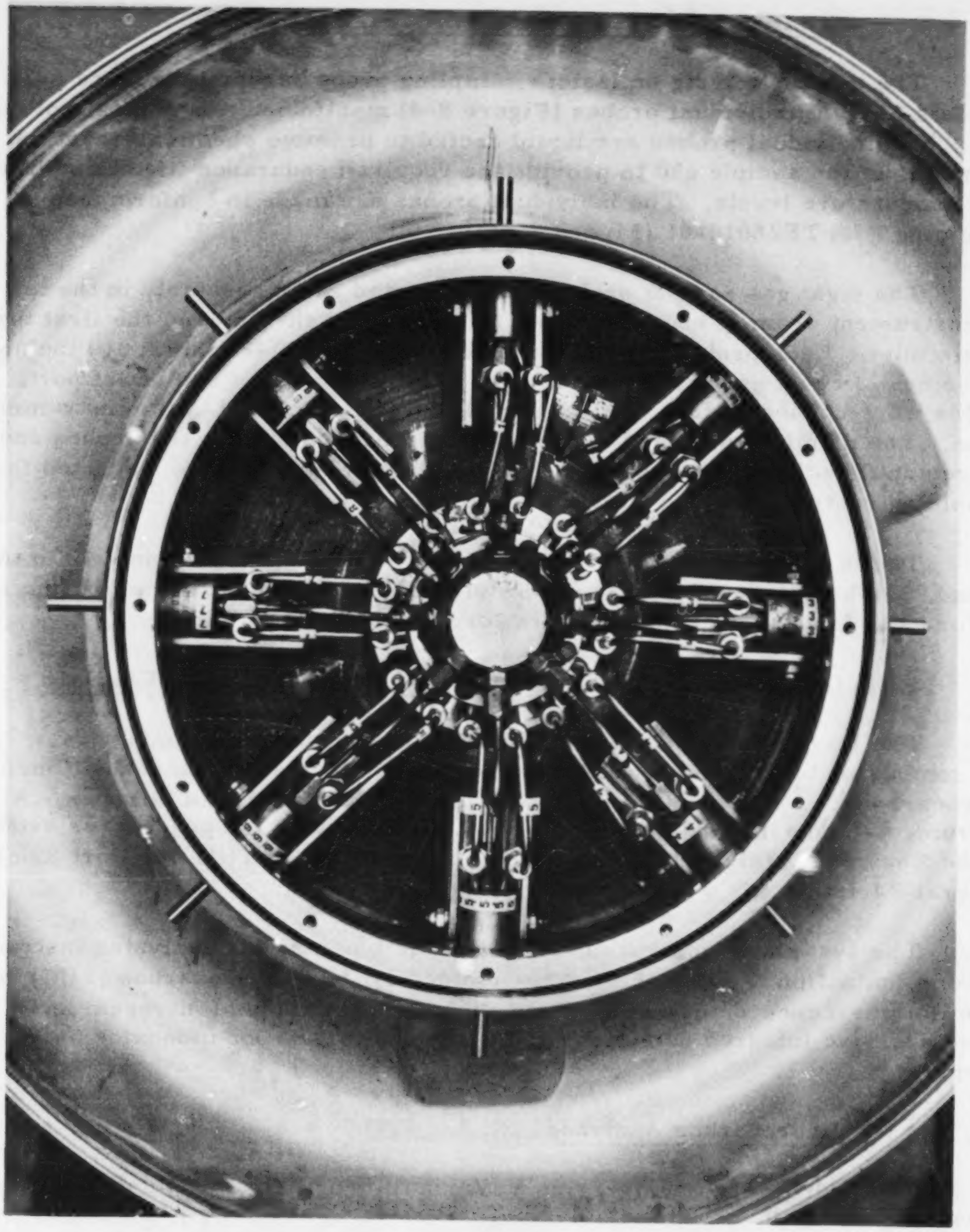


Figure 8-3. Combustor Rig Gas Sample Probe Assembly.

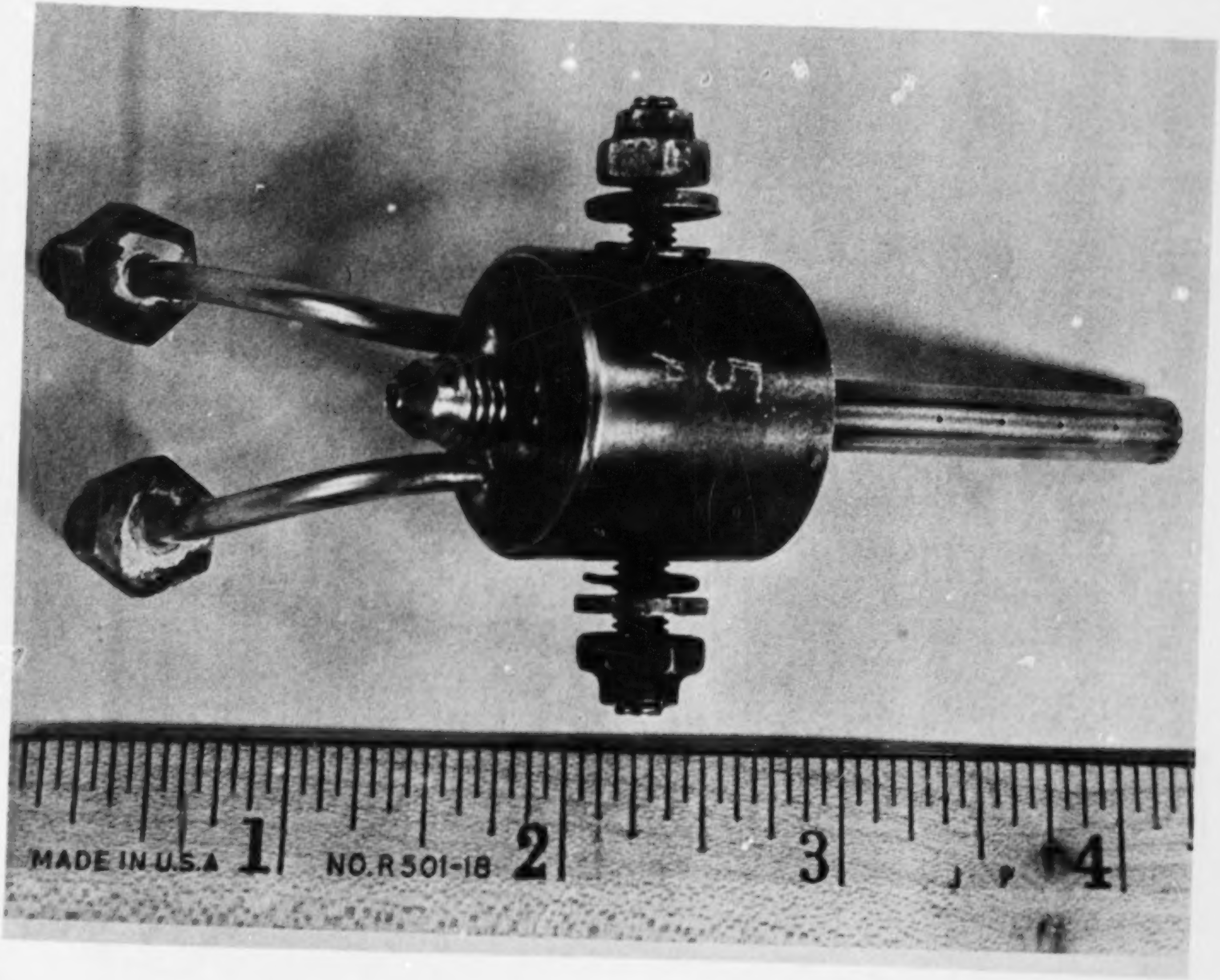
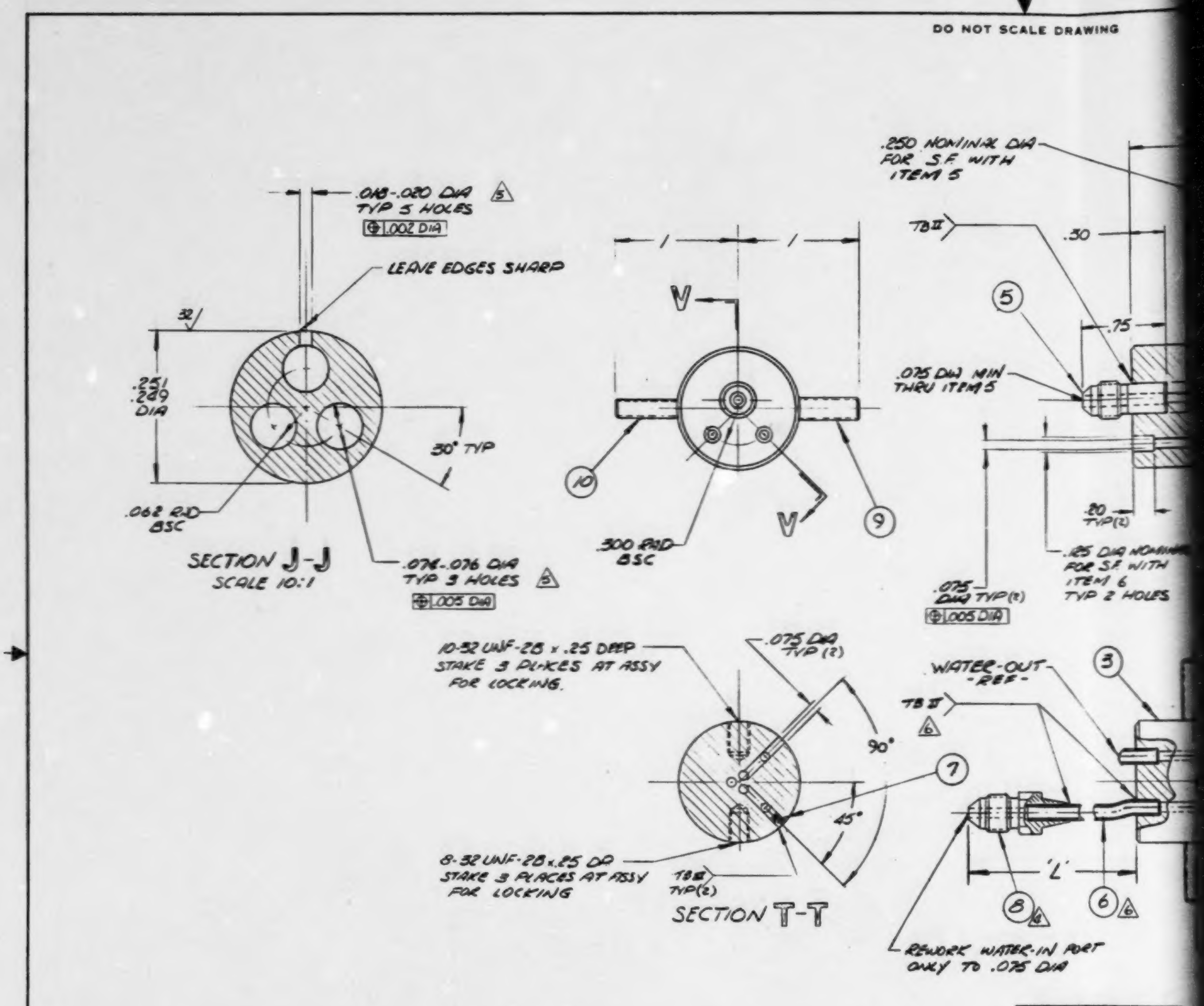

5
A
MADE IN U.S.A
1
NO.R501-18
2
3
4

Figure 8-4. Combustor Rig Gas Sample Probe - TE 28010-01.


DO NOT SCALE DRAWING
.018-.020 DIA 5 TYP 5 HOLES
.002 DIA
LEAVE EDGES SHARP
32
.251 .289 DIA
30° TYP
.062 RAD BSC
SECTION J-J
SCALE 10:1
.078-.076 DIA TYP 3 HOLES 5
.005 DIA
1
1
V
V
10
9
.300 RAD BSC
.250 NOMINAL DIA FOR S.F. WITH ITEM 5
TB II
.30
5
.75
.075 DIA MIN THRU ITEM 5
.20 TYP(2)
.125 DIA NOMINAL FOR S.F. WITH ITEM 6 TYP 2 HOLES
.075 DIA TYP(2)
.005 DIA
10-32 UNF-2B x .25 DEEP STAKE 3 PLACES AT ASSY FOR LOCKING.
.075 DIA TYP(2)
90°
45°
7
8-32 UNF-2B x .25 DP STAKE 3 PLACES AT ASSY FOR LOCKING
TB III TYP(2)
SECTION T-T
WATER-OUT -REF-
3
TB II 6
'L'
8 4
6 6
REWORK WATER-IN PORT ONLY TO .075 DIA

TABULAR DIM.	
ASSY NO.	DIM 'L'
-01	2.00

7 PRESSURE TEST WATER LINE AT 50 PSIG

6 TUBE LENGTH SPECIFIED PER INSTALLATION. SEE TABLE

5 MFR. BY E.D.M. ONLY

4 MAY BE MADE FROM 1/8 TUBE SIZE FLARE FTG - CRES

3 MAKE FROM 1/8 TUBE SIZE FLARE FITTING - CRES

2 MATL: ANY AVAILABLE 300 SERIES CRES.

1 THIS DRAWING SUPERSEDES PSK 18696

NOTES:

1

NEXT ASSY | MODEL

APPLICATION

Figure 8-5. Individual Gas Sample Probe - Rig Style Print - TE28010-01

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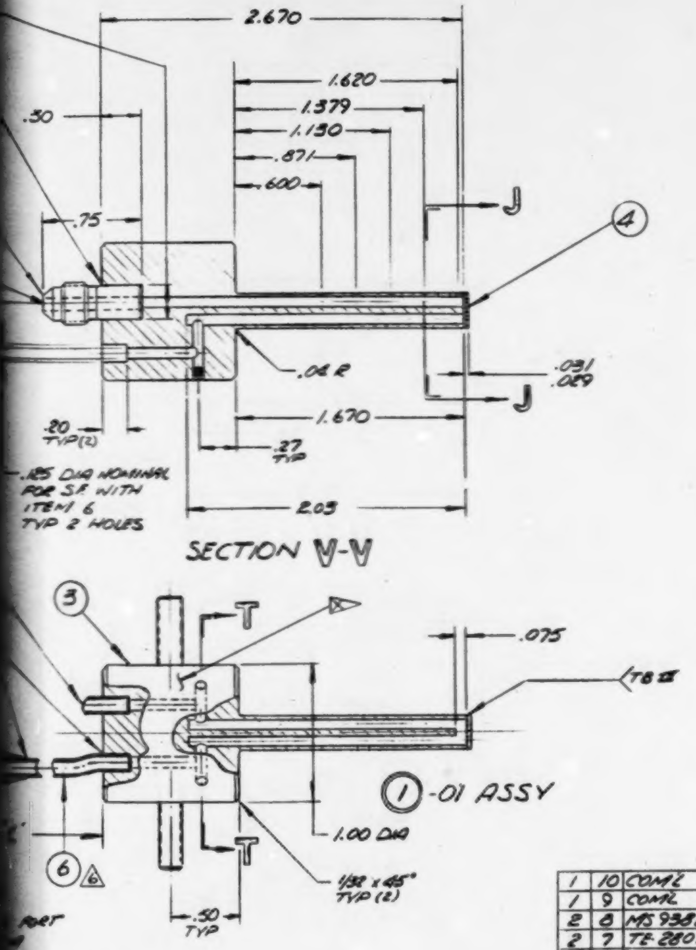
A

DRAWING

REVISIONS					
E.O.	ZONE	LTR	DESCRIPTION	DATE	APPROVED



2.670
1.620
1.579
1.150
.871
.600
.50
.75
J
J
4
.04 R
.031
.029
.20
TYP(2)
1.670
.27
TYP
.125 DIA NOMINAL
FOR S.F. WITH
ITEM 6
TYP 2 HOLES
2.05
SECTION V-V
3
T
T
.075
TB II
1-01 ASSY
1.00 DIA
1/32 x 45°
TYP (2)
6
6
.50
TYP
PORT

...ULAR DIM.	
...NO.	DIM 'L'
...1	2.00

QTY REQD	ITEM NO.	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL OR NOTE	ZONE
1	10	COML	SETSCREW 8-32 x 3/16 LG	CRES	
1	9	COML	SETSCREW 10-32 x 3/16 LG	CRES	
2	8	MS 9381-02	COUPLING, TUBE	4	
2	7	TE-28010-07	PLUG .075 DIA x 1/32 LG	2	
A/R	6	TE-28010-06	TUBE 1/16 OD x .020 W	2 6	
1	5	TE-28010-05	FITTING (1/16 TUBE)	3	
1	4	TE-28010-04	END CAP	2	
1	3	TE-28010-03	BODY	2	
	2				
☒	1	TE-28010-01	PROBE ASSY		

LIST OF MATERIAL

AVCO LYCOMING DIVISION
STRATFORD, CONNECTICUT

PROBE, GAS ANALYSIS
ASSEMBLY

SIZE	CODE IDENT NO.	
D	91547	TE-28010

SCALE 2/1
WT
SHEET 1 OF 1

FIN. TREAT PASSIVATE
PROCESS P6233
INSPECTION P6804
FRAC ± 1/32
201
MATL SEE L/M
63

CHECKED H.W.R. 6/1/76
DRAWN BY TWAROG 5/28/76
6/1/76
6/1/76
6/1/76

1
NEXT ASSY
MODEL
APPLICATION

TE-28010

B

is controlled by the main control panel, oven temperature control module, and electrometer module.

The main control panel provides the central location for power to the instrument, temperature control of the oven and detector and temperature monitoring of all thermal areas. An isothermal controller proportionally controls the oven at temperatures up to 400°C and is stable to $\pm$ .2°C of the set temperature. Conversion of the small current changes at the output of the ionization detector to a representative voltage is accomplished by the JFET (junction field effect transistor) electrometer. Range and attenuation are also selectable from this unit.

The FID detector consists of a flame-tip assembly attached to the detector base. Located above the flame tip is the collector (anode) electrode. The cathode probe which supplies the ionization voltage and ignitor coil is attached to the flame tip. Flame ignition is accomplished by applying a voltage to the ignitor coil.

Hydrogen (60 percent He Balance) is burned in an atmosphere of air (supplied HC free air). As the sample is introduced to the hydrogen flame through the base of the detector, the hydrocarbons are burned and, consequently, produce negative ions and electrons which are collected on the anode. The collection process produces an electrical current proportional to the burned material which is then amplified and converted to a readable voltage.

The purchased model 1400 was a standard injection-type gas chromatograph instrument requiring modification for continuous flow sampling. The injection column was removed, the carrier gas port plugged, and a two-position multiport, electric-operated stainless steel valve with flow restrictors was installed. The valve is located just upstream of the detector with sample, calibration, and bypass lines connected to the appropriate ports.

8.5.2 Chemiluminescent NO/NO_x Analyzer

The NO/NO_x analyzer is a Bechman 951H chemiluminescent analyzer. The instrument operating at a continuous flow through the detector analyzes either the NO or NO_x content of the sample.

In the NO mode of operation, a portion ($\approx$ 10%) of the nitric oxide is converted to electronically excited NO_2 by oxidation with molecular ozone. A photomultiplier detector senses the emission of photons and the NO_2 returns to the nonexcited state, thus generating a low-level signal.

The NO_x mode operates in a similar manner; however, before reacting with the ozone, the sample is routed through the converter to change NO_2 to NO. The resulting signals of the photomultiplier are amplified to drive the panel meter and external recording system.

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The analyzer contains an internal bypass system for maximum response and pressure-dropping flow restrictors for pressurized sample inlet and atmospheric analysis.

8.5.3 CO/CO_2 Non-dispersive Infrared Analyzer (NDIR)

Two Horiba NDIR continuous-flow analyzers are used to measure the carbon monoxide and carbon dioxide concentrations contained in the sample. Models AIA-21-AS and AIA-21 were used for CO and CO_2, respectively. The cells are shock-mounted in the system to reduce pump vibration effects.

Both instruments operate on the principle of infrared (IR) absorbtion by the component of interest. A dual beam of collimated light passes through two parallel cells, one containing the sample and the other a nonabsorbing reference gas. A rotating optical chopper interupts the signals which are then directed to the detector where the difference in energy absorbed becomes a function of the concentration present in the sample. Sensitized detectors and an optical filter minimize interference from nonwanted components.

The AS-type detector used for carbon monoxide (in addition to its optical filters) uses a dual detector system to minimize water and CO_2 interference. The IR beam is passed through two detectors, the first of which contains the larger portion of the absorbed signal from the required component and the second the absorbed signal of the other components. The two signals are electrically subtracted by means of a mixing amplifier to produce a signal that is proportional only to the carbon monoxide content.

The sample cells are heated and temperature-controlled for stability and prevention of water condensation. The signals from both detectors are amplified and conditioned by separate electronic modules contained in a common chassis for meter display and auxiliary data system output.

8.5.4 Sample Flow System Description

Figure 8-6 is a schematic showing the flow path of the sample and calibration gases as they enter and pass through the system. A heated Metal Bellows pump (model 602) draws the sample from the probe at the rate of approximately 40-LPM and compresses the sample to 10 psi. A system bypass regulator maintains the pressure and bypasses the unused flow (20 LPM). A pressure gage and flow meter are used for continuous monitoring of the values. The remaining flow is split into three separate samples: 1) a THC sample, 2) a NO_x sample, and 3) a CO/CO_2 sample.

The THC sample ($\approx$ 5 LPM) passes through a heated (150°C), sintered, stainless steel filter before entering the control valve in the FID oven. The sample pressure is dropped from 10 to 5 psi by a sintered stainless steel (FRIT) restrictor in the valve. A second FRIT restrictor, also in the valve, allows

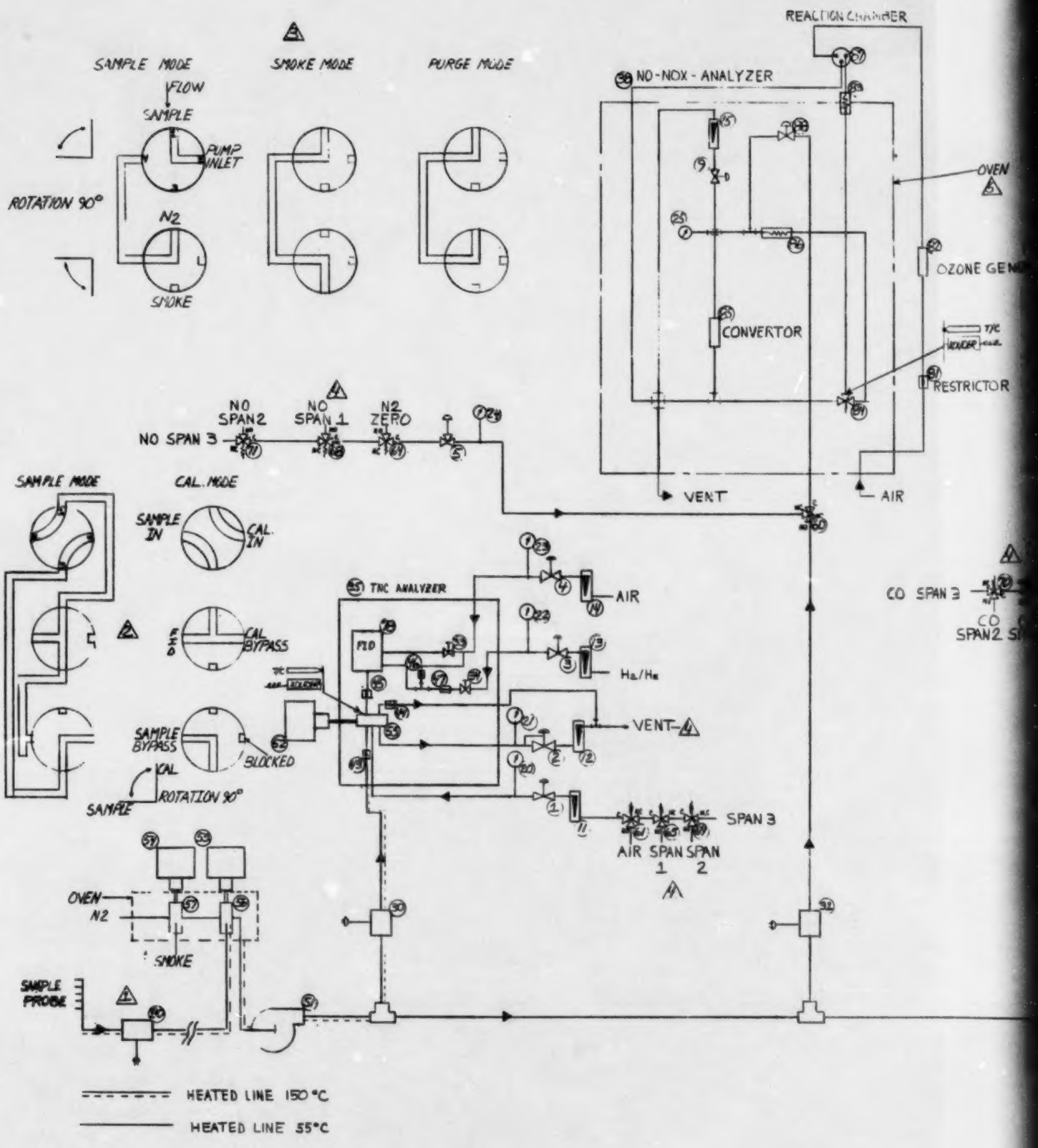
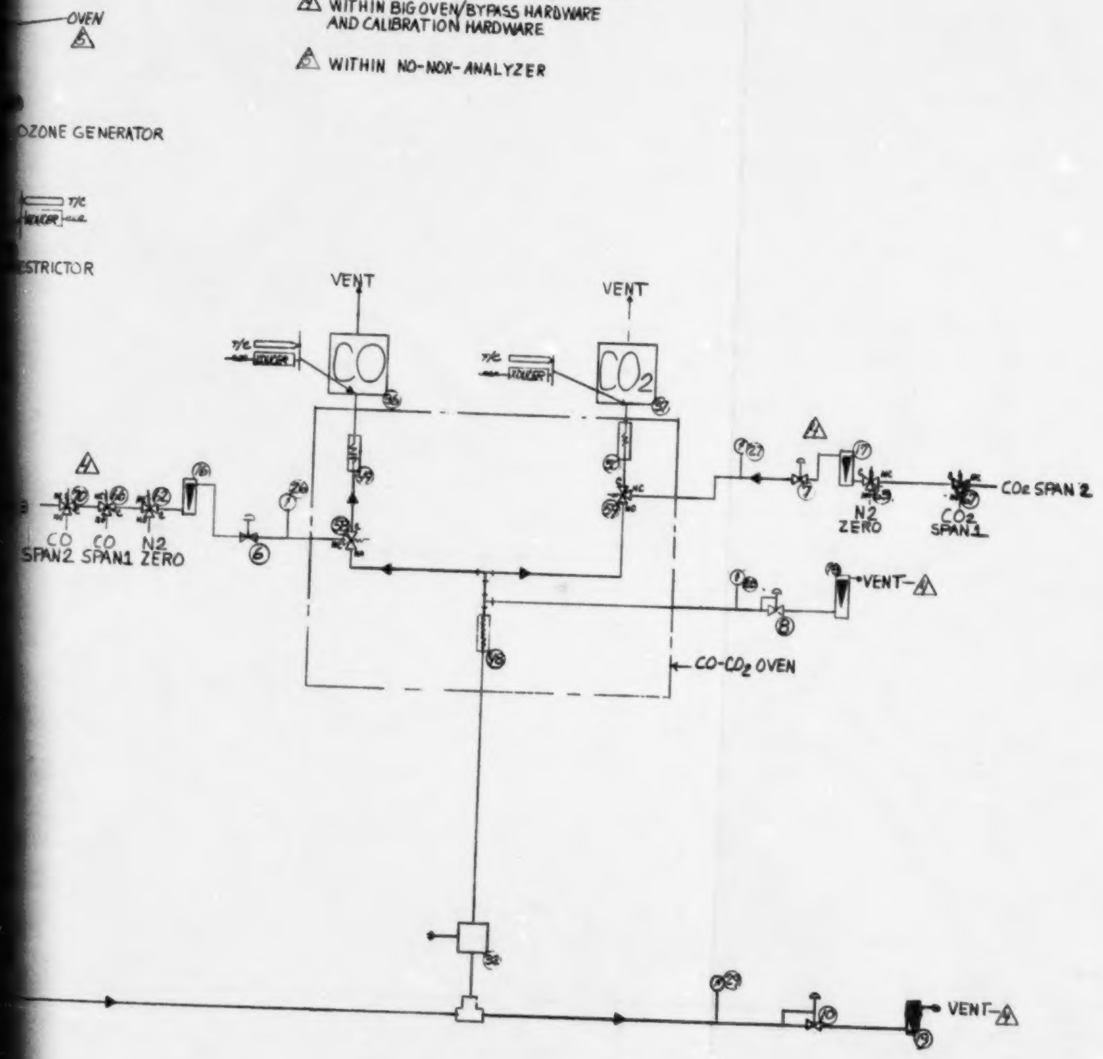

SAMPLE MODE
SMOKE MODE
PURGE MODE
FLOW
SAMPLE
PUMP INLET
ROTATION 90°
N2
SMOKE
REACTION CHAMBER
NO-NOX-ANALYZER
CONVERTOR
OVEN
OZONE GEN
T/C
RESTRICTOR
VENT
AIR
NO SPAN 3
NO SPAN2
NO SPAN 1
N2 ZERO
SAMPLE MODE
CAL. MODE
SAMPLE IN
CAL. IN
CAL BYPASS
SAMPLE BYPASS
BLOCKED
CAL
SAMPLE
ROTATION 90°
THC ANALYZER
FID
AIR
H2/He
VENT
SPAN 3
AIR
SPAN 1
SPAN 2
CO SPAN 3
CO SPAN2
OVEN
N2
SMOKE
SAMPLE PROBE
HEATED LINE 150°C
HEATED LINE 55°C

Figure 8- 6. DS18 Emission Measurement Flow Schematic.

A

NOTES

1. SEPARATE FROM DATA SYSTEM
2. VALVE OPERATION — HC, SAMPLE/CAL
3. VALVE OPERATION — SAMPLE, PURGE, SMOKE
4. WITHIN BIG OVEN/BYPASS HARDWARE AND CALIBRATION HARDWARE
5. WITHIN NO-NOX-ANALYZER


OVEN
5
OZONE GENERATOR
T/C
HOLDER
ESTRICTOR
VENT
VENT
CO
CO2
T/C
HOLDER
T/C
HOLDER
56
57
4
4
CO
SPAN2
CO
SPAN1
N2
ZERO
16
6
26
59
58
50
27
7
17
N2
ZERO
CO2
SPAN1
CO2 SPAN 2
8
VENT-4
CO-CO2 OVEN
38
VENT-4
10
9

B

approximately 18 cc/min. to enter the FID. The remaining flow is directed to the control oven where the HC bypass regulator maintains the 5 psi pressure at the sample restrictor, and the pressure and flow can be monitored.

The NO_x sample (approximately 2.5 LPM) is filtered by a second heated stainless steel filter and the pressure dropped to 7 psi by the NO_x regulator before entering the analyzer. A bypass regulator and flow meter built into the heated section of the instrument maintain an operating pressure of 4 psi and the bypass flow at 2 LPM.

The CO/CO_2 sample is filtered prior to entering the CO/CO_2 oven. In the oven, a FRIT restrictor drops the pressure from 10 to 5 psi while passing a total flow of 9 LPM which, in turn, is split three ways. FRIT restrictors at the input of the CO and CO_2 cells flow 2 LPM each and drop the pressure to just above ambient. The remaining 5 LPM is directed to the control oven where the regulator, pressure gage, and flow meter control and allow monitoring of the conditions.

All instrument exhaust (except HC) and bypass flows are vented from the rear of the control oven and pass through small jars before venting to the atmosphere. The moisture condenses in the jars and not the vent lines which would cause unwanted back pressure to the analyzers.

Two electrically operated valves at the input of the system can be selected to either allow the sample to enter the pump and through the system as described above or to be redirected to the DS16C smoke sampling system described in paragraph 8.7. A third mode of operation (N_2 purge) permits nitrogen gas to back-flow the sample line and probe to prevent fuel contamination during the start-up or shutdown cycle.

8.5.5 Calibration Flow System Description

The zero and span gases are input to the system at the rear of the control oven. Up to three span gases for THC, CO, and NO_x and two for CO_2 and zero gas for each can be input. Solenoid valves in the control oven, operated from a switch panel, direct the zero or span gases to each instrument as required. The SAMPLE/CAL solenoid valves at the input of each instrument, also controlled from the switch panel, allow independent instrument calibration selection.

Pressure regulators in the control oven for each set of calibration gases maintain a pressure level consistent with sample pressures under operating conditions. Flow meters and pressure gages are provided to assure consistent unrestricted operation.

8.5.6 System Temperature Control

Each instrument has self-contained heating elements and control circuitry. The THC instrument controller maintains the FID oven at 160°C and the detector base at 210°C. The NO_x analyzer is heated to 60°C and both the CO and CO_2 cells at 55°C. The three sample filters also contain independent heating elements and control units.

All system components contain heating elements, such as bar and finned heaters for the ovens and pump and nickel chromium wire for sample lines, which are controlled by five separate temperature control units. A thermistor-coupled feed-back circuit with current limit and temperature set point is used.

The pump heads, Sample/Smoke/Surge valve and 150°C stainless steel sample line (Dekoron 2152-06, 3/8 electro-trace) to the THC analyzer use two of the controllers to maintain these devices at 150°C. Two other controllers maintain the control oven and CO/CO_2 oven at 55°C which in turn heat the solenoid valves, flow meters, gages, regulators, and stainless steel tubing contained within them. The 55°C stainless steel sample lines (Dekoron 2150-04, 1/4 electro-trace) which connect the control oven to the instruments and filters are controlled by the remaining controller.

A temperature selection and read-out system is used to monitor the thermocouples installed in the various devices for proper operating temperature. In addition, a scanning/indicating unit has been incorporated in the system to periodically check sample lines for open circuits. A light indication on any of the switch positions, which corresponds to a specific section of line, indicates an unheated area that can be easily traced without numerous temperature measurements.

8.5.7 Detector Flow-Variance Compensation

In addition to the front panel sample pressures and temperature monitoring equipment, electrical transducers have been provided. Strain gage-type pressure transducers and type "K" thermocouples are installed near the inlet of each detector. The pressure transducers are installed in a "cool" location for stability and connected to the inlets by means of small stainless steel tubing. The thermocouples are in the sample flow stream.

The THC and NO_x analyzers are extremely sensitive to flow variations and require compensation for any differences. The transducers measure the pressure just upstream of the sample flow restrictors in both analyzers for recording and correction later by the data reduction program.

During each 30-day calibration or when one of the restrictors is changed, the pressure is set at a number of different values and the corresponding responses of the instrument to a span gas at these pressures are recorded. Correction factors are developed for input to the data reduction program to compensate for any deviation between calibration and sample pressures recorded during test operation. This technique also alleviates the need for time-consuming precise system adjustments or loss of data from most regulation problems which may occur.

The CO and CO_2 detectors are not flow-sensitive; however, the transducers in these instruments provide recorded assurance that no data errors due to downstream blockage are present.

Thermocouples measure the sample temperature entering the detectors for recorded indications of sufficient and consistent values during calibration and sampling. The thermocouples are referenced to 32°F by an electronic reference junction before being input to the acquisition system.

8.5.8 Data Output

Three means of monitoring and recording the data output from the instruments are available with the system: 1) continuous plots 2) digital readout, and 3) voltage signals for automatic acquisition systems.

Two dual pen plotters continuously record the four instrument signals representing THC, CO, CO_2, and NO_x emission levels. The primary purpose of the plotters is to determine stability of the set condition before acquisition.

A voltmeter selector switch and range indicator permit access to the instrument outputs for manual recording without interruption of the automatic recording system. The range indicator identifies, at a glance, the range being used. This section is used to monitor the calibration repeatability and record test values for input to a computing calculator for correlation of measured and computed fuel-air ratio.

The primary data acquisition is made using the DS8 Portable Digital Data Acquisition System discussed in paragraph 8.6. A total of sixteen values are output by the system for recording four values for each instrument. Signals are output from each instrument representative of the emission levels. Range signals of 1, 2, 3, or 4 volts are output by each instrument depending on the selected range. The data reduction program uses the range information for the proper selection of calibration, span gas, and instrument curve for use in computing the emission levels. The sample pressure transducer and thermocouple outputs of each instrument make up the remaining signals.

8.6 PORTABLE DIGITAL DATA ACQUISITION SYSTEM - DS8

This system was used in both the engine testing and combustion rig testing portions of the program to record the output from the DS18 emission measurement system.

This data system accepts, digitally converts, and records multiple inputs of pressure, temperature, and other types of voltage data. The voltages were derived from the gas analysis instrument outputs and the pressure sensor temperature monitoring thermocouples. The system is a mobile unit adaptable to all component and engine test areas, including the ones used for this program.

The signals are connected to an input scanner programmer. The scanner provides channel selection to the integrating digital voltmeter (via the amplifier) and external programming for the voltage range, sample period, and stabilization delay. Special control functions such as a pressure-scanner advance and actuator-position advance are also provided by the scanner.

The data system output is in two forms. The first is printed output available for examination by personnel at the test site, while the second output is a five-level IBM punched paper tape that is converted to a card form output for input into the main data reduction programs.

8.7 PORTABLE SMOKE MEASUREMENT DATA SYSTEM - DS16C

This system, shown schematically in Figure 8-7, uses the soiled-paper technique of collecting smoke particles to determine the smoke number present in the engine exhaust. The systems portability allows its use in any of the engine or combustor test areas.

The equipment and techniques conform to EPA standard 40 CFR, Part 87. As indicated, the sampling equipment is a self-contained unit with all the necessary control, pressure, temperature, and flow-measuring instruments. The sample is maintained above the dew point temperature to prevent water condensation.

The exhaust gas is sampled through the probe and passed through the filter paper (Whatman No. 4) producing a dark circular spot proportional to the smoke concentration in the gas. The spot is then measured for reflected light and compared with standard reflection values to determine the smoke number.

The spot reflection is determined by use of a Macbeth reflection densitometer, Model RD-400, which is a digital-readout, reflection densitometer equipped with four selectable filters for color and visual density measurements from 0 to 2.5 density units. The digital readout displays numerically to the hundreth of a unit and holds each reading in the display until the next measurement is made.

8.8 EMISSION MEASUREMENT TECHNIQUES

8.8.1 Background and Compliance

Many approaches to measure gas turbine emissions have been used by various manufacturers to satisfy individual requirements. The need for improvements in emission instruments technology and measurement techniques has long been realized by Lycoming and attempts to contribute to their advancement continued with this program.

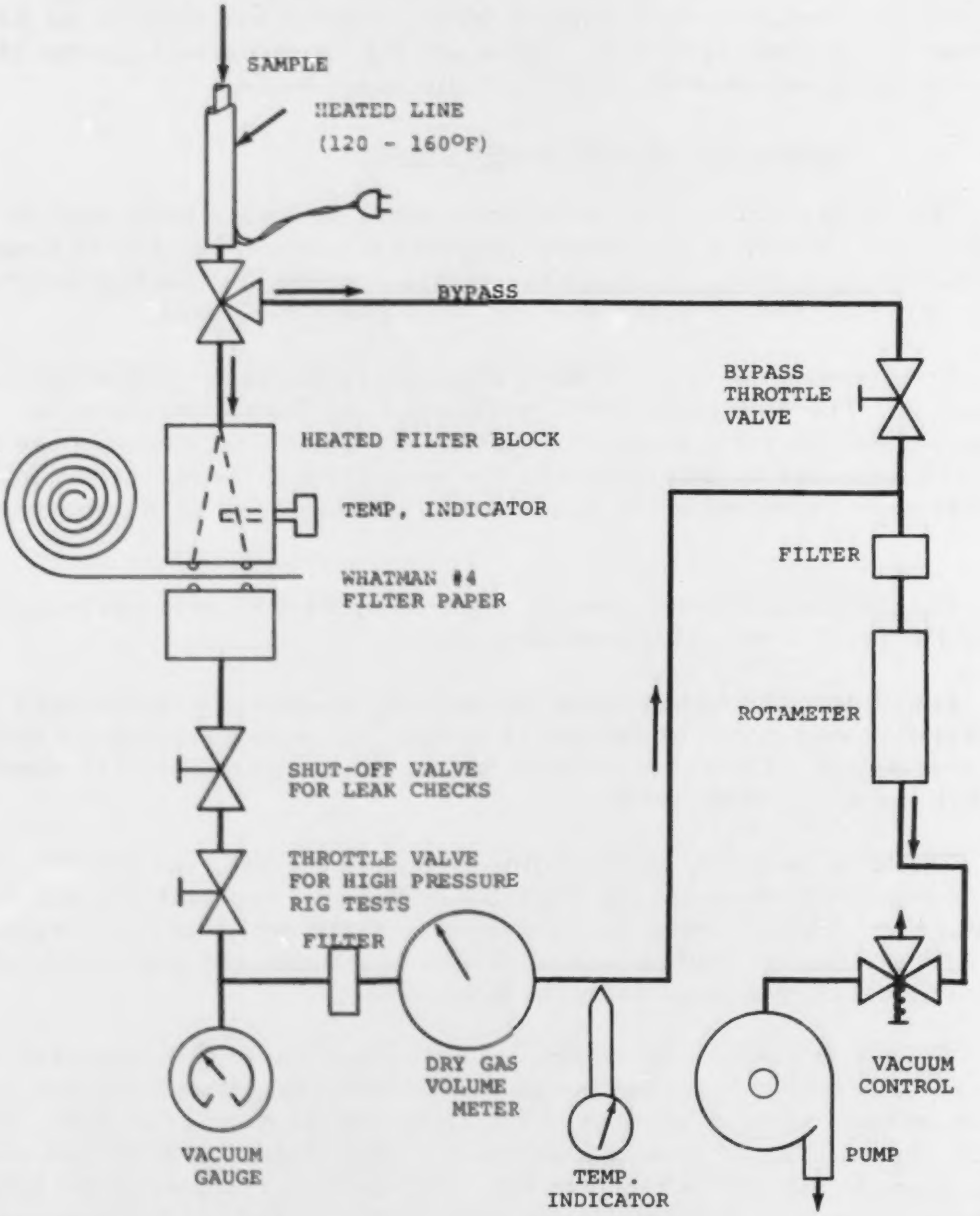

SAMPLE
HEATED LINE
(120 - 160°F)
BYPASS
BYPASS
THROTTLE
VALVE
HEATED FILTER BLOCK
TEMP, INDICATOR
WHATMAN #4
FILTER PAPER
FILTER
ROTAMETER
SHUT-OFF VALVE
FOR LEAK CHECKS
THROTTLE VALVE
FOR HIGH PRESSURE
RIG TESTS
FILTER
DRY GAS
VOLUME
METER
VACUUM
CONTROL
VACUUM
GAUGE
TEMP.
INDICATOR
PUMP

Figure 8-7. DS16C Portable Smoke Measurement System-Schematic.

The procedures for emissions test were established by the EPA and published in the Federal Register on 17 July 1973. These procedures were used in the majority during this program. Where deviations were necessary, specifically for combustor rig testing, a formal request was made to the EPA. The techniques used during both the engine and rig test programs and the results of the various emission system checks are discussed below.

8.8.2 Calibration and Instrument Checks

The 30-day instrument checks and calibrations were performed in accordance with Part 87 of the Federal Register at intervals during both engine and combustor rig testing. Although the regulation requires that the analytical accuracy of the calibration gases be ± 2%, ± 1% gases were used.

The blending tolerance of the ± 2% gases is normally ± 5% of the requested concentration. The ± 1% gases were purchased from Scott Environmental Technology under the trade name ACUBLEND TM which (by definition) has a "zero" blend tolerance as determined by the sensitivity of the measuring instrument. The bottles were delivered in the majority as less than 1.5% of the requested value.

Each of the instrument checks required by Part 87 were performed using the 1% "zero" blend gases described above.

In addition, the hydrocarbon and NO/NO_x analyzers were checked for output variation as a result of changes in sample pressure as discussed in the system description. Typical correction factors for each analyzer are shown in Tables 8-1 and 8-2, respectively.

The least-squares, straight-line fit of both the THC and NO/NO_x analyzers were well within the 2% allowable deviation. Repeatability in the calibrations of each instrument was observed over the period of this program. The CO and CO_2 instrument calibrations were also repeatable and also agreed closely with the original curves supplied by the manufacturer.

The effect of different oxygen concentrations on the THC analyzer was found to be consistently less than the required three-percent and five percent deviation, respectively, of propane in 10% O_2 and N_2 to propane in AIR. The technique of premixing a small amount of air (20 ml/min.) with the fuel allows the instrument to satisfy the requirement. This method reported by K. Schofield(2) had previously been used satisfactorily on other FID analyzers at Lycoming.

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(2) Problems with Flame Ionization Detectors in Automotive Exhaust Hydrocarbon Measurements, Keith Schofield, Environmental Science and Technology, Volume 8, Number 9, September 1974, PP. 826-834

TABLE 8-1. HYDROCARBON ANALYZER PRESSURE CORRECTION FACTORS

FID Sample Pressure (1)	HC-Correction Factor (CF) (2)
21	1.552
22	1.422
23	1.326
24	1.238
25	1.150
26	1.088
27	1.022
27.3	1.0
28	0.961
29	0.9109
30	0.0619
31	0.8179

(1) The values listed are the millivolt output of the transducers. These values only represent pressure and are not indications of psia or psig; i.e., 27.3MV = 5 psi

(2) $CF = \frac{\text{Output @ } 27.3}{\text{Output @ } x}$ x = 21, 31

TABLE 8-2. NO/NO$_x$ ANALYZER PRESSURE CORRECTION FACTORS

FID Sample Pressure (1)	Correction Factor (CF) (2)
11.5	1.192
12.0	1.142
12.5	1.117
13.0	1.090
13.5	1.063
14.0	1.043
14.5	1.018
14.9	1.0
15.5	0.969
16.0	0.951
16.5	0.935
17.0	0.918

(1) The values listed are the millivolt output of the transducer. There values only represent pressure and are not indications of psia or psig; i.e., 14.9 MV = 4 psig

(2) $CF = \frac{\text{Output @ 14.9}}{\text{Out @ x}}$ x = 11.5, 17

The CO analyzer water vapor and CO_2 interferences checks were made using nominal values of 5% and 4%, respectively. The standard bubble-jar technique of saturating nitrogen-zero gas was used. The error to both water vapor and CO_2 was consistently less than 1.5% on the lowest range (100 ppm).

In addition to the standard instrument checks, Lycoming subscribes to the Scott Cross-Reference Service. The service provides a convenient means of checking instrument performance, calibration procedures, and comparative accuracy to others analysis. A bottle of gas supplied by Scott Environmental Technology contains an unknown concentration of propane, CO,and CO_2 to be analyzed. The results are returned to Scott where the data from each subscriber are tabulated, statistically analyzed, and issued as reports. The results of those bottles analyzed during the contract period are shown in Table 8-3.

8.8.3 Daily Pre-Test Checks

8.8.3.1 Instrument Operation Checks and Adjustments - After the instrument and system warmup time, each instrument was checked for response to each zero and span gas and compared with the previous day's calibration. Adjustments were made if found to be necessary. At no other time during the day's test were the electrical zero and spans adjusted. Experience with the instruments indicates a significantly greater stability if unchanged.

8.8.3.2 Clean Line and Pressure Check - A check of the sample line for contamination was performed prior to and following each engine test cycle and rig-test day. Clean filters were installed. Zero air and a propane span gas were alternately input to the probe-end of the sample line, and the response of the THC analyzer was compared with the known value. Deviations of more than 2 percent were not observed. The regulation indicates a check of the sample line condition be performed with each hourly calibration. A deviation from the procedure was requested and granted by the EPA. It was indicated that the sample line reaches an equalibrium condition at each point and to introduce zero and span gas would unnecessarily disturb this condition. Depending on the levels of emissions, a considerable length of time could be required to achieve a ligitimate zero. Restabilization of the line to the sample condition is then required before the point can be recorded.

The line was also checked for smoke contamination by taking a sample with the probe connected. Twenty liters were drawn through the filter paper at normal operating pressures and temperatures.

To pressure check the sample line from the probe to the system, the line was capped and the system switched to N_2 purge. The N_2 bottle valve was turned off, and a drop-off in pressure, as shown by the gage, indicated any possible leak. The data system was not pressure-checked since it operates

TABLE 8-3. 1976-DIESEL CROSS-REFERENCE SERVICE(1) ANALYSIS

Report No.	Avg (No. Data)	Median	Est of STD Deviation	Est of STD Error	Avco Lycoming DS18	(CT) Scott GC
1						
HC (PPm)(2)	177.2 (12)	177	± 2.82	± 0.813	179.4	177.3
CO (PPm)	529.8 (14)	535.5	± 20.1	± 5.38	507	512
CO_2 (%)	3.107 (13)	3.1	± 0.0653	± 0.0181	3.09	3.15
2						
HC (PPm)	676.5 (11)	675.0	± 8.36	± 2.52	665.4	681
CO (PPm)	168.7 (13)	167.0	± 9.95	± 2.76	155.7	160
CO_2(%)	8.258	8.17	± 0.289	± 0.0802	8.69	8.26
3						
HC	30.35 (10)	30.25	± 1.26	± 0.399	30.59	30.07
CO	10,162 (12)	10,200	± 222.2	± 64.1	— (3)	10,200
CO_2	1.86 (13)	1.88	± 0.084	± 0.023	1.95	1.86
4						
HC	857.1 (15)	844.0	± 53.95	± 13.93	834.2	846
CO	1009 (18)	1001.	± 28.2	± 6.64	1018	1022
CO_2	5.92 (16)	5.93	± 0.079	± .020	5.96	6.038

1. Scott Specialty Gases, a Division of Scott Environmental Technology Inc.
2. Hydrocrabons as Methane
3. Beyond Range of Instrument

above atmosphere from the pump output to the input of each instrument.

8.8.3.3 NO_x Efficiency Test - The efficiency of the converter used to change NO_2 to NO in the analyzer was checked each test day. The tester was built and used in accordance with the description and procedures specified in the regulation. Efficiencies greater than 95 percent were common, and no values were ever below the 90 percent requirement

8.8.3.4 Residence Time Check - Figure 8-8 is a schematic of the residence time check setup. A three-way selector valve with two throttle valves attached was connected to the end of the sample line. With the system pump on, the two throttling valves were adjusted to achieve test operating pressures and flows at the system equally from both directions through the selector valve.

After injecting a generous quantity of either propane, CO, CO_2, or NO into the 283-liter (10 ft.^{3}) mylar bag, the bag was connected to one side of the selector valve. The selector valve was then quickly switched from the atmosphere side to permit the system to draw the sample from the sample bag.

The output of the appropriate instrument was recorded on the strip-chart recorder operating at one second per inch . The system operator marked the plot at the point the valve was switched. The test was repeated three times to obtain a representative average. The response times for the engine and combustor rig tests were: CO - 6.0 sec., CO_2 - 3.6 sec., HC - 10 sec., and NO_x - 5.9 sec.

The sample transfer time from the probe to the system was calculated and found to be about 1.5 seconds for both the engine and rig test.

8.9 SENSORS AND PROBES FOR AEROTHERMODYNAMIC DATA

Measurement of the operational control parameters and inlet conditions was made with specially designed probes and sensors, which were developed over many hundreds of hours of engine and rig testing. Recording of engine test data values was accomplished by the use of an IBM 1800 computer-based, data-acquisition and computation system. Combustor rig test data were recorded using a Lycoming-designed digital data acquisition system.

Total pressures were sensed using averaging impact type rakes. Static pressures were measured with sharp-edged ports on duct walls. Liquid flows were measured with precalibrated turbine-element flowmeters. Temperatures were measured with I.C. or C.A. thermocouples, both shielded and unshielded, depending on application. Calibration of the wire used conformed to NBS standards, for ± 4°F measurements.

Humidity in the combustor rig testing was measured by withdrawing a sample of the air at the inlet to the rig by means of a single-point total-impact probe inserted 15 centimeters into the airstream.

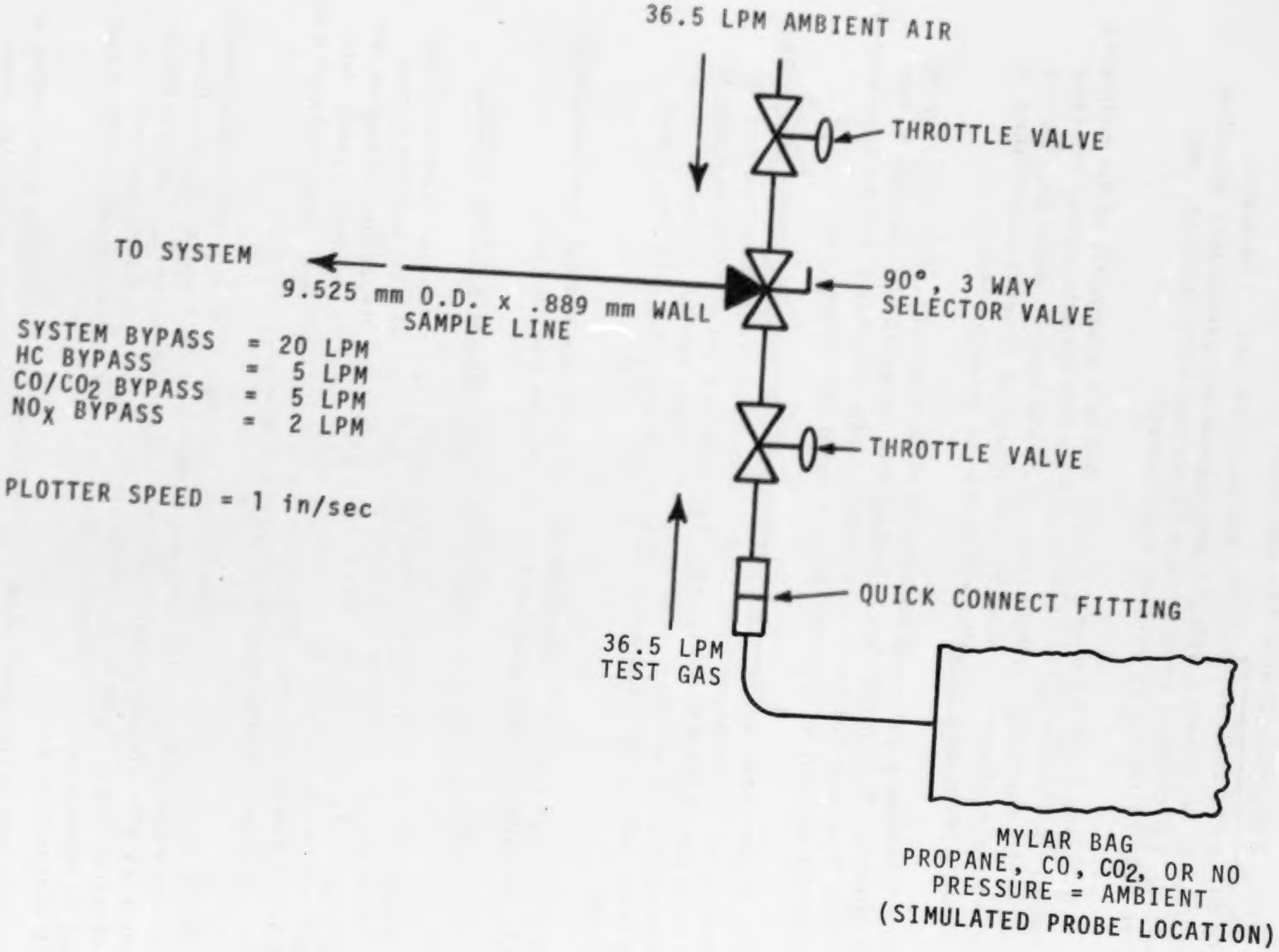

36.5 LPM AMBIENT AIR
THROTTLE VALVE
TO SYSTEM
9.525 mm O.D. x .889 mm WALL SAMPLE LINE
90°, 3 WAY SELECTOR VALVE
SYSTEM BYPASS = 20 LPM
HC BYPASS = 5 LPM
CO/CO_2 BYPASS = 5 LPM
NO_X BYPASS = 2 LPM
THROTTLE VALVE
PLOTTER SPEED = 1 in/sec
QUICK CONNECT FITTING
36.5 LPM TEST GAS
MYLAR BAG
PROPANE, CO, CO_2, OR NO
PRESSURE = AMBIENT
(SIMULATED PROBE LOCATION)

Figure 8-8. Residence Time Check Schematic.

The humidity distribution was investigated at selected conditions prior to the test program by traversing the combustor inlet dewpoint sample probe across the channel and noting the change. With the water spray nozzles located some 12 meters upstream and two 90-degree turns in the piping system, no deviation was expected or observed.

8.10 MULTIPLE INPUT DIGITAL DATA ACQUISITION SYSTEM - DS10

This data acquisition system was used during the combustor rig testing to record all data other than emissions measurements.

The system accepts, digitally converts, and records multiple inputs of pressure, temperature, and other voltage data by means of an integrating digital voltmeter. The inputs were derived from sensors connected to various locations on the combustor development test rig. The system has the capacity to read 200 independent signals from any of the test cells located in Lycoming's Building 19 complex.

The combustor configuration can use part of the 200 input signals in the following manner: one absolute pressure transducer scanned through 48 pressure ports; two differential pressure transducers (up to ± 25 psid) each scanned through 24 pressure port pairs; and two frequency (fuel flow) signals. The remainder of the input signal recording capability is used for thermocouples of other miscellaneous signals.

The transducers are installed in a temperature-controlled cabinet consisting of one absolute scanner with a 48-port scanning capability, and two differential scanners with 24 ports each. The cabinet is located near a valve panel and connected to the common of each valve by plastic tubing. The valve selector system permits easy and fast turnaround time to one of the five test areas. Pressure ranges up to 200 psia are acceptable for such a system, although 150 psia is the normal working limit.

Pressure transducer calibration is accomplished by selected, known high-quality (± .02%) pressures as part of scanned data. In this manner, a multipoint calibration curve is recorded for each data point and is used in computer program correction techniques. Repeatability of better than ± .002 psi of pressures less than 30 psia are generally achieved. For pressures higher than 30 psia, ± .01 psi repeatability is generally possible.

The differential pressure scanners are used for accurate measurement of differential pressures. Calibration pressures, normally 0 and 2 psi, are input to the first two ports of the scanner and recorded by the data system to permit computer correction routine calculations. Individual signal conditioning to obtain the desired output voltage for the corresponding calibration pressure is also used for these transducers. Accuracy of better than ± 0.1% is achieved while repeatability is found to be less than ± .002 psi.

Thermocouple cold-junction compensation is accomplished through a 36-point, 32°F electronic reference junction. A series of thermocouple jack panels allows any of the five combustor testways to be selected. Reference junction cycling and validity are checked by a precision 150°F signal source which is recorded with every data scan.

The data system's output is in two forms. The first form is printed output for examination by engineering personnel at the test site. The second output is five-level, I. B. M.-punched paper tape for later conversion and input into data reduction computer programs. An additional feature of the system is the ability to have the output printed automatically in engineering units (psia psid, °F, and rpm) to provide the engineering evaluation of the data before the normal data scan is taken.

8.11 ENGINE CELL DATA SYSTEM IBM 1800

The IBM 1800 system was used to record engine operational and ambient parameters during the engine-test portion of the program. Application of the IBM 1800 Data Acquisition and Control System (DACS) that supports test facility is discussed below.

Four test cells are presently being serviced, wherein each pair of cells is separated by a control room designed to direct the activities of the adjacent cells. Each control room is equipped with its own CRT unit for online monitoring and an alphanumeric keyboard for communication with the IBM 1800 DACS.

The IBM 1800 DACS provides for the continuous monitoring of gas turbine engines under test and the permanent recording of a family of engine parameters.

Test monitoring is achieved through the acquisition (scan), logical treatment, and CRT display of parameters having a response time goverened by time-dependent constraints and through the detection of critical conditions (alarm system) having an even faster response time.

Test data recording includes the acquisition, logical treatment, and output of all parameters instrumented for a given engine test. All defined conversion and performance calculation s are also output. Recording provides onsite printer and magnetic tape output with all parameters appropriately identified; this not only provides a permanent record of the test data for future reference, but also permits processing of the data by data reduction and engine cycle match-point performance programs on a host computer.

The acquisition system is equipped with a 32K memory, two 512K word discs, a magnetic tape unit, a card reader, and a punch and line printer.

As many as 300 variables can be acquired, computations made, and output supplied to the various devices for off-line analysis. The complete acquisition time to acquire the engine data occurs in approximately 15 seconds of initiation.

Selected variables were converted by the system to engineering units and used to compute the required parameters for the CRT update at the engine control station.

8.12 HUMIDITY MEASUREMENT

Humidity was measured by General Eastman (Model 1200 AP) dewpoint meters that work on the principle of condensation on a temperature-controlled mirror.

The series 1200 dewpoint hygrometers are thermoelectrically cooled, optically detected, automatically controlled, condensation (or dewpoint) hygrometers. The principle of operation is shown in Figure 8-9.

The condensate detection mirror is illuminated with a high-intensity, solid-state, light-emitting diode (LED). A photodetector is configured so as to monitor the specular (direct) component of the light from the mirror. A separate LED and photodetector combination are used to compensate for any thermally induced changes in the optical components. The photodetectors are arranged in an electrical bridge circuit such that the specular detector is fully illuminated when the mirror is clear of dew and sees reduced light as dew forms on the mirror, due to scattering losses.

An optical offset is designed into the bridge such that a large bridge output current is developed whenever the mirror is in the "dry" condition. The bridge output is amplified and used to control the direct current to the thermoelectric cooler, causing the mirror to cool toward the dewpoint. As dew begins to form on the mirror, the optical bridge is driven toward its balance point, causing a reduction in the specular light, causing the bridge output to decrease, and the cooling current to reduce. A rate feedback loop within the amplifier is employed to insure critical response, and the system quickly stabilizes at a condition wherein a thin dew or frost layer is maintained on the mirror surface, i. e., the dew or frost point. A precision thermometer-element is embedded within the mirror to monitor this dewpoint temperature directly.

The condensation hygrometer is a fundamental method for measuring water vapor, thereby affording a degree of accuracy not available with other methods. Additionally, the repeatability of the instrument can be checked at any time by opening the control loop and allowing the mirror to heat and the dew

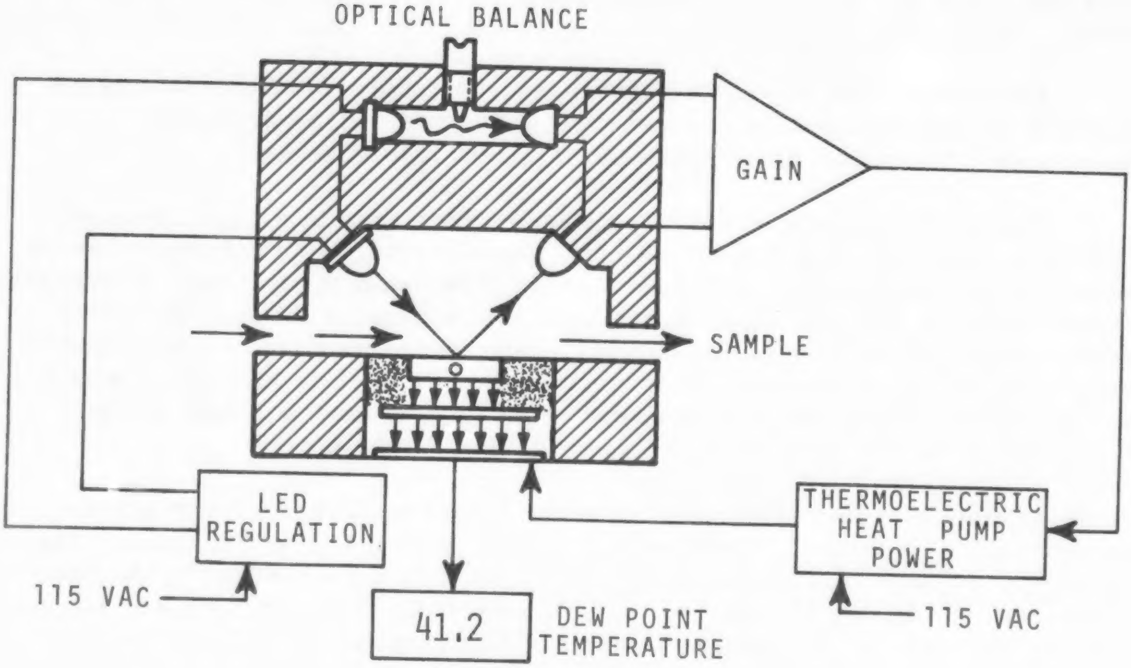

OPTICAL BALANCE
GAIN
SAMPLE
LED REGULATION
THERMOELECTRIC HEAT PUMP POWER
115 VAC
41.2
DEW POINT TEMPERATURE
115 VAC

Figure 8-9. Dew Point Meter Operational Schematic.

to evaporate, and then reclosing the control loop. Long-term accuracies in the order of ± 0.2°F are common with the condensation hygrometer, thus making it suitable as a laboratory reference instrument.

During the engine test program, the air samples were extracted from the test cell. During the rig-test program, samples were taken at two stations in the testway upstream of the combustor rig.

Upstream of the humidity-conditioning spray nozzle, a small sample of the air was extracted from the testway through a standard Kiel-type pressure probe. The probe was connected via a 6.35 mm (0.25 in.) O.D. stainless steel unheated but insulated line to a General Eastman (Model 1200AP) dewpoint sensor for measuring the incoming or ambient humidity. A similar probe at the combustor inlet was connected to a second sensor; however, this connecting line was heated to maintain the temperature above the dewpoint resulting from the added water.

Both sensors were mounted in the heated temperature-controlled box and maintained above the dewpoints. Line restrictions ahead of the sensors and placement of the sensors some 6 meters from the probes were used to control the pressure, temperature, and flow within the limits of the sensors.

The sensors were electrically connected to the dewpoint meters located in the control room. The meter provided digital readout for set-point operation. A secondary calculation of the dewpoint was also made using measured water flow through the conditioning spray nozzles and the moisture content in the ambient air. The water was measured with calibrated turbine-element flow meters. A comparison of the two measurement methods is presented in Section 11.3.

9.0 COMBUSTOR RIG TESTING

9.1 GENERAL

The combustor rig-test portion of the program was conducted on a full engine combustion system under controlled inlet conditions to obtain emissions data over a wide range of simulated engine environments. Tests were run in the idle to 1.5 times idle range and at approach conditions under actual engine conditions of temperature, pressure, and humidity. Twenty-two different environmental conditions were covered at each of the three power settings run. The high power conditions shown in Table 7-2 were not run.

Lycoming's ALF 502 combustor rig was used in the aerodynamic component test laboratory to accomplish this testing. The rig, laboratory facilities, and operating procedures are described in detail below.

9.2 COMBUSTOR TEST RIG

9.2.1 Rig Description

The Lycoming ALF 502 combustor component test rig provides a functional simulation of the engine flow conditions to allow determination of operational characteristics as they would occur in the full engine. The same rig has been used for the development tests of the combustion systems for Lycoming's T55 and ALF 502 engine families.

The combustor test rig shown installed in the testway in Figure 9-1 consisted of the engine combustor liner, housing, fuel manifold assembly, and the inlet/exit transition sections. A modified compressor diffuser, combustor outer curl, and instrument drum are mounted to the inlet duct as shown in Figure 9-2.

The exit-plane instrument drum on which the gas sample probes are mounted is connected to a centershaft through which the sample gas flow, cooling fluid, and cooling air are fed.

The combustor liner housing, and fuel manifold assembly with flow divider mount to the inlet flange. The inner curl mounted to the water-jacketed exhaust section and exit transition duct complete the flow path and assembly.

The rig is designed to accept engine hardware without modification and operate at pressure levels up to 10 atmospheres with maximum inlet and exhaust temperatures of 315°C (600°F) and 1200°C (2200°F), respectively; this allows direct simulation of combustor inlet conditions for idle, 1.5 idle, and approach modes. The rig also includes the instrumentation necessary to define the inlet and exit operating parameters.

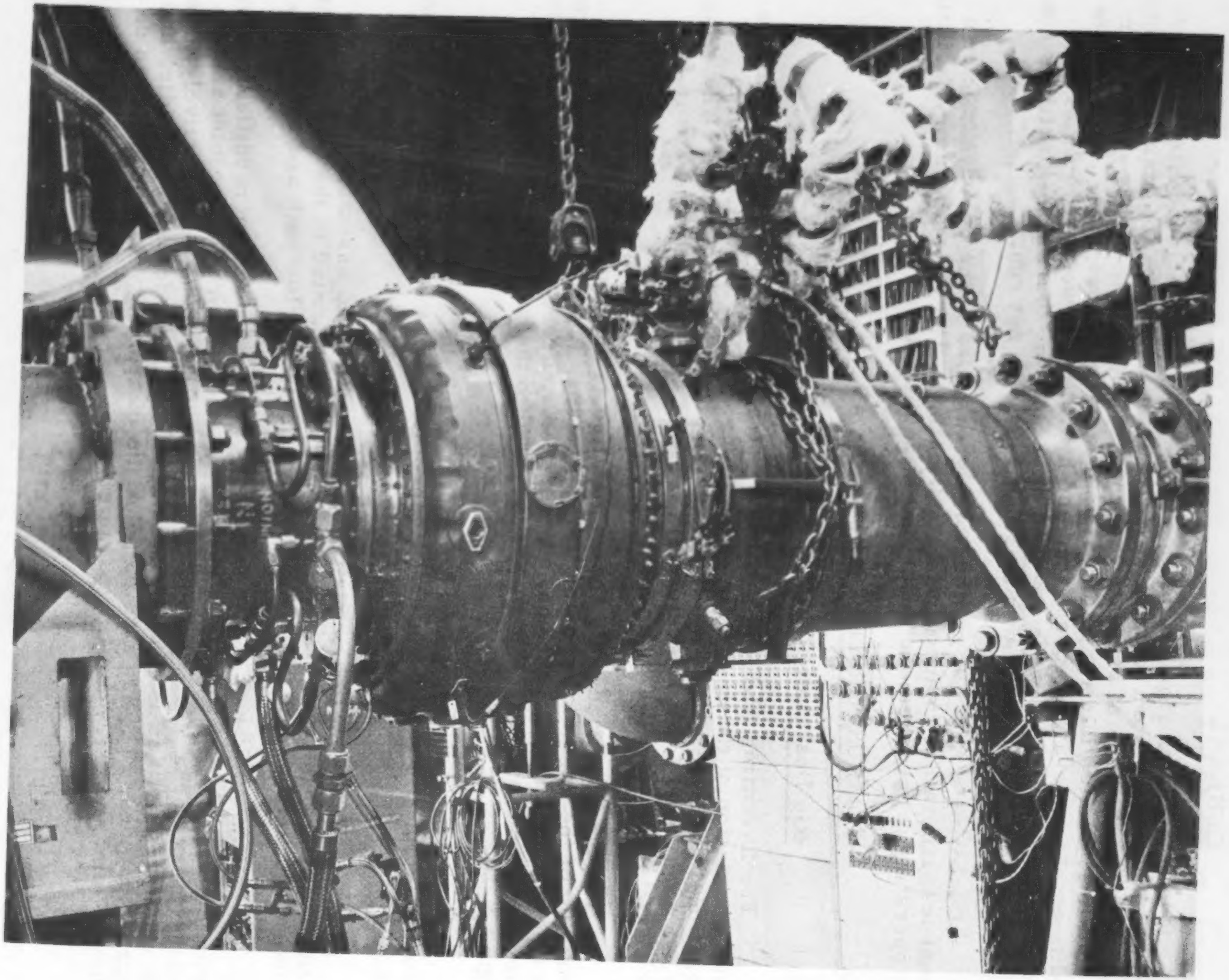


Figure 9-1. ALF 502 Combustor Test Rig Installation.

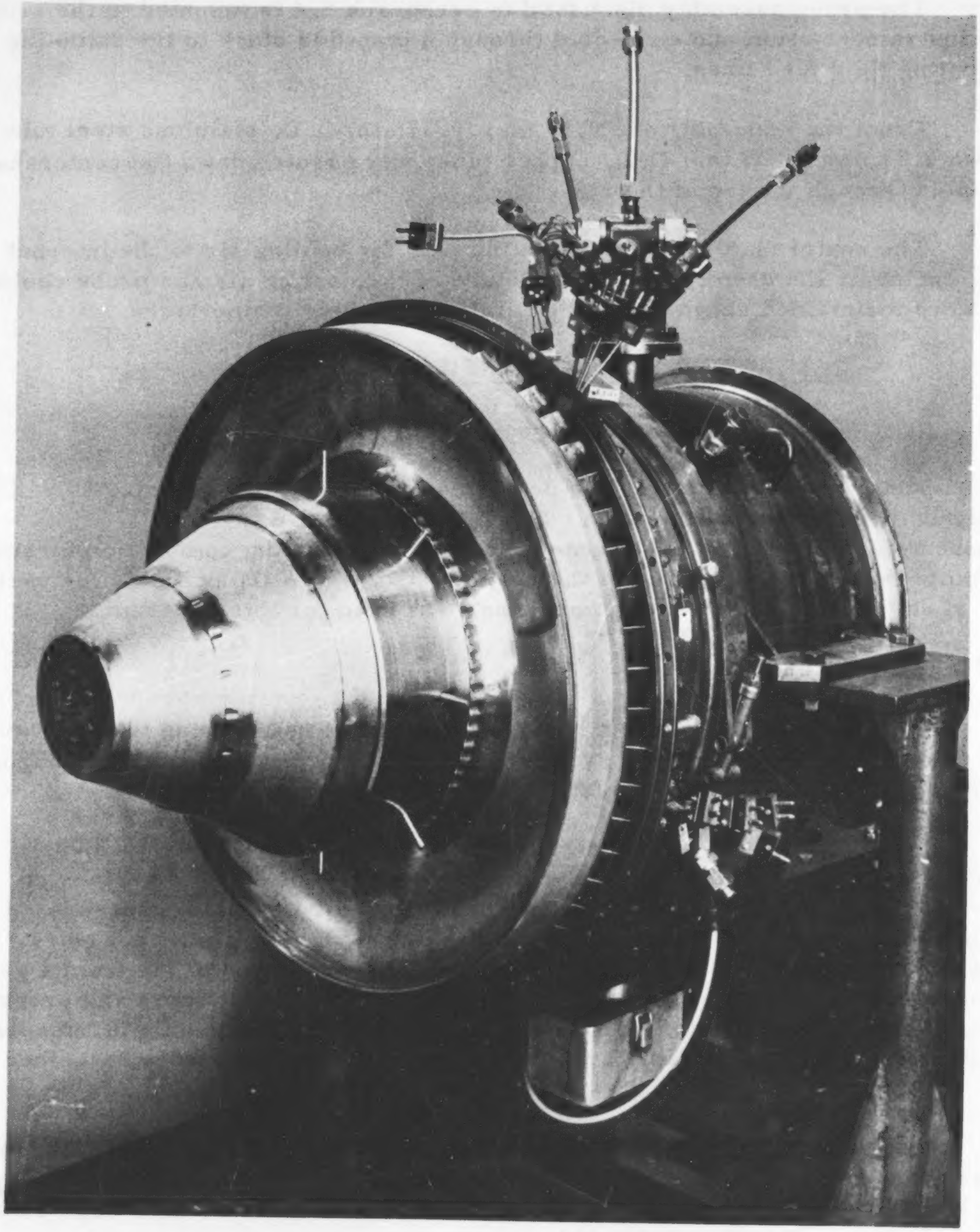


Figure 9-2. Combustor Rig Assembly - Partial.

9.2.2 Rig Gas Sampling System

The probe assembly discussed in paragraph 8.4 is mounted in the exit plane instrument drum and connected through a manifold block to the sampling and cooling fluid feed lines.

From the manifold, one 9.53 mm (0.375 in) O.D. stainless steel tube and two 6.35 mm (0.25 in.) O.D. copper tubes were routed down the centershaft and exited through the top of the rig.

The centershaft also serves as the path for cooling air to the internal rig parts, including the drum. The temperature of the cooling air and probe cooling fluid were maintained above the 150°C minimum sample temperature.

9.3 COMBUSTOR TEST FACILITIES

9.3.1 General

The combustor rig test (Task I) was performed in Lycoming's Building 19 Aerodynamic Laboratory complex. This area is used for engine component evaluations and development programs, including combustion, turbine and compressor systems. One of the seven testways (TW-1) available for various types of combustor and operating conditions was used for this program.

9.3.2 Air Supply

Two different pieces of air-moving equipment used during this test were: 1) an electric motor-driven industrial style compressor and 2) a multiple engine-driven T55-L-11 engine compressor.

The Allis-Chalmers industrial style centrifugal compressor supplies 10 lb/sec of air at up to 3 atmospheres and with the aid of electric heaters at temperatures between 93°C (200°F) and 315°C (600°F). Constant pressure control (±.02 psi) is accomplished by automatic sensing of rig inlet pressure acting to control the main compressor exit valve. The source of air from a gas turbine engine-driven T55 compressor was used for the higher flows and pressure levels. This facility presently provides 21 lb/sec of air at 96 psia and temperatures up to 315°C (600°F). The same pressure control system previously described is used.

Shop air or air extracted from the T55-L11 compressor, depending on rig pressure level, is supplied at approximately 0.5 lb/sec to the rig for cooling of the combustors internal components. This air was also passed through a bank of electric heaters for temperature control.

9.3.3 Rig Air Humidification System

To achieve the humidification requirements for this program, it was necessary to provide a means of injecting water into the inlet air and measuring the resulting humidity. An available pressurized water source was used to supply a spray-manifold installed upstream of the combustor.

The high-pressure water (up to 500 psi) was filtered and supplied to the water-spray manifold (Figure 9-3) through a series of three fluid-measuring turbine elements (0-50, 0-500, and 0-5000 lb/hr). These manifolded elements were remotely selected and the flow controlled from the control room.

The water-spray manifold located some 12 meters from the combustor inlet consisted of four nozzles of the type shown in Figure 9-4. Three of the nozzles were sized for a maximum water flow of 600 lb/hr and one for 200 lb/hr maximum.

Individual shutoff valves provide selection of any combination of the nozzles for sufficient flow and control. The nozzles were specifically designed and built at Lycoming to achieve the insertion depth and control required for this application.

9.3.4 Fuel System

Jet A fuel was supplied by the main plant farm fuel tanks to the Building 19 fuel distribution and control system.

The fuel was fed to the combustor by the pumping and control system using a positive-displacement pump and pneumatically controlled metering valves. A fuel-element manifold consisting of 0-50, 0-500, and 0-5000 lb/hr turbine elements, selectable from the control room, was used for all fuel measurements. The element output was displayed at the operation console and recorded on the digital data acquisition system for later data reduction.

Before entering the combustor, two steam heat exchangers were used to control the temperature of the fuel at a level comparable with those found during engine testing (Task II). Steam flow to the heat exchangers was pneumatically controlled from the control room.

9.3.5 Gas Sample Probe Cooling

Emissions measurements are generally more difficult in combustor rig tests than in an engine test. The severity of the conditions experienced by the gas sample probes, sometimes in excess of 1100°C during operation, required that cooling techniques be implemented.

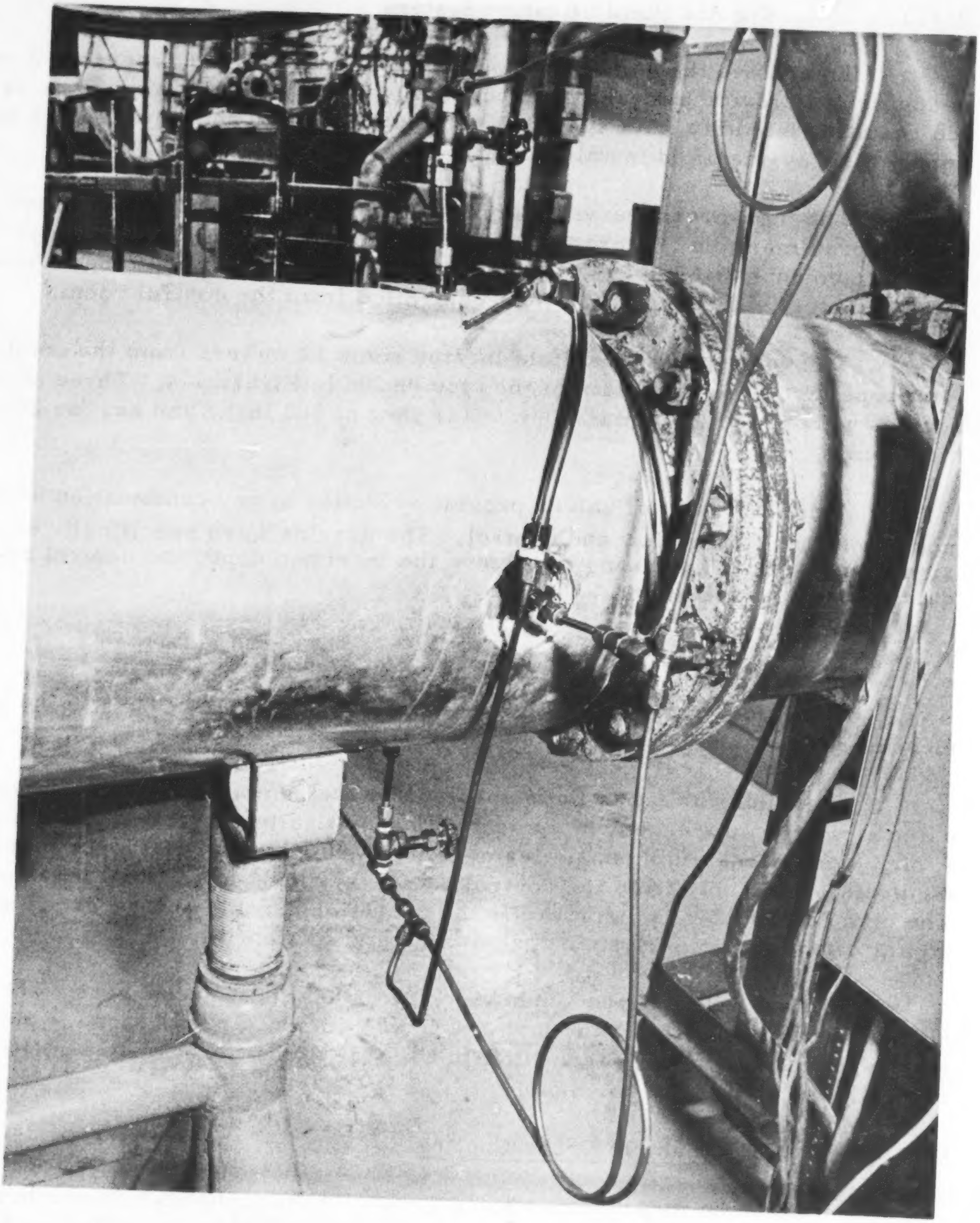


Figure 9-3. Water Spray Installation.

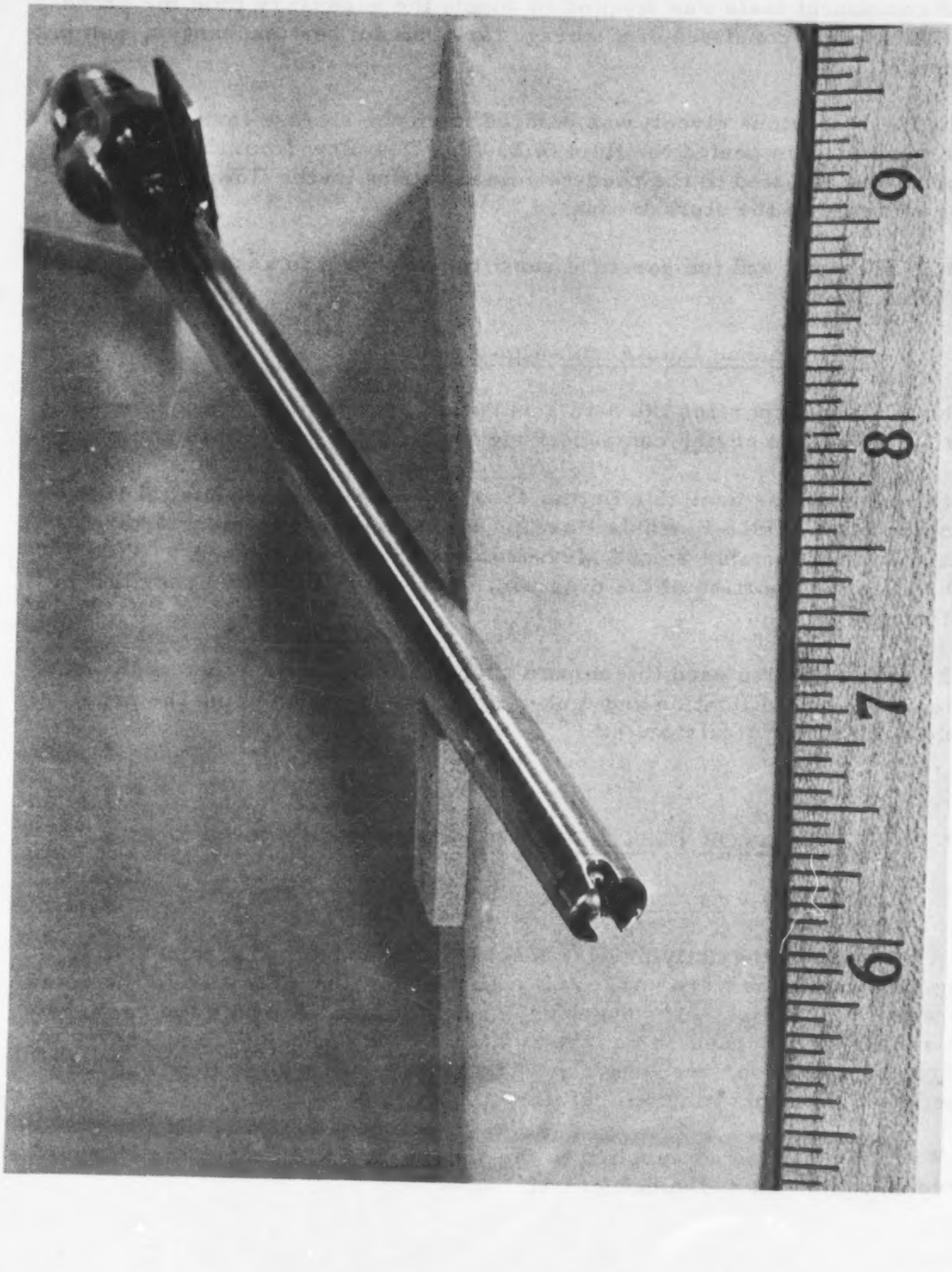


Figure 9-4 Water Spray Nozzle.

A portable, fluid heating stand commonly used for many experimental engine and component tests was adapted to supply the necessary fluid for probe cooling. The system consisted of a storage tank, steam heat exchanger, pump, and flowmeter.

The fluid (ethylene glycol) was pumped from the storage tank to the heat exchanger where steam heated the fluid to 150°C. The flow from the exchanger to the probes was adjusted to the predetermined setting on the flowmeter and the excess returned to the storage tank.

Fluid pressure and temperature sensors were used to assess and control operating conditions.

9.3.6 Performance Data Acquisition Area

This area incorporates the data acquisition system used for performance investigation of various engine component rig tests in the Building 19 complex.

Of these systems available in this area, the DS8 and DS10 Digital Data Acquisition Systems, DS18 Portable Gaseous Emission Measurement Data System, and DS16C Portable Smoke Measurement System were used during the rig testing portion of the program. These systems are described in detail in Paragraph 8.

The area was also used to compute such parameters as water addition requirements for humidification and fuel-air ratio correlation using the programmable computing calculator.

9.4 COMBUSTOR TEST PROCEDURES

9.4.1 Start-Up Procedure

After each of the daily pretest checks discussed in paragraph 8.8.3, the appropriate facilities were employed to supply flow and pressure to the combustor at a convenient light-off condition. The preheaters for both the cooling and the main air were turned on and the system allowed to stabilize at 150°C and the first T3 condition, respectively. The probe cooling fluid flow was also started and heated to operating temperature (150°C).

With nitrogen purge supplied to the sample line and probe, the combustor was ignited and the required condition set.

9.4.2 Humidity Control Procedure

The combustor air dewpoints of both meters were compared with each other and the National Weather Service at Sikorsky Airport which is approximately 1.6 kilometers from Lycoming. Agreement within 1°F was normally observed.

Using the ambient dewpoint and orifice parameters, the quantity of moisture in the air and actual airflow to the combustors were computed. The difference between the actual and required moisture content was then used to determine the amount of water (lb/hr) to be added.

The appropriate flow element (0-50, 0-500, or 0-5000 lb/hr) and combination of spray nozzles were selected. The operator controlling the pneumatic water valve from the control room adjusted the water flow until the displayed value corresponded to the computed flow.

As the water was added, the dewpoint measured at the combustor inlet would increase and approach the required value. Being the prime indicator of the moisture content, the dewpoint corresponding to the water concentration required was set by altering the water flow.

9.4.3 Fuel Temperature Control

The temperature of the fuel was controlled by the two steam heat exchangers described earlier. Fuel entering the manifold was maintained at 107°C (225°F) for consistency with the average level observed during the engine test phase of the program.

9.4.4 Combustor Performance Data Acquisition

The combustor operating parameters were recorded on the DS10 Digital Data Acquisition System described in Paragraph 8.10. The data recorded at each condition included fuel flow, fuel temperature (element), fuel temperature (manifold), orifice pressure (2), orifice pressure drop (3), orifice temperature (2), inlet total pressure (3), inlet total temperature (4), water flow, and two dewpoints.

9.4.5 Emissions Data Acquisition

The emission data, including hydrocarbon, carbon monoxide, carbon dioxide, oxides of nitrogen, and smoke, were measured using the DS18 Portable Gaseous Emission System and the DS16C Portable Smoke Measurement System. These systems are described in detail in Section 8. The voltage signals from the emission instruments were recorded on the DS8 Portable Digital Data Acquisition System also described in Section 8.

Each instrument was calibrated by inputing the appropriate zero and span gases to each range being used and digitally recording the responses. Successive calibrations were compared to assure that zero and span shifts did not exceed two percent during the test period.

The emission system was selected for the sample mode, and the pneumatic-actuated control valve at the input to the sample line was adjusted for the proper pressure and flow to the system. System pressures, temperatures, and flows were monitored to verify that each were within operating limits.

Visual observation of the emission levels recorded on the strip chart was used to determine stabilization. When stable, the data were recorded at 15-second intervals (two samples with the NO/NO_x analyzer in the NO mode and two in the NO_x mode). Each scan consisted of recording the output of the four emission instruments, the sample pressure and temperature of each, and the ranges being used. All of the data were taken within one hour of the last instrument calibration.

While the emissions were being digitally recorded, they were also being manually recorded and converted to engineering units. Each value was examined for consistency with expected trends, and the emission fuel-air ratio was computed. The measured fuel-air ratio was computed and compared with the emissions value to determine representiveness of the sample.

At the completion of the emission sample acquisition, the sample was redirected for a smoke sample. After a one-minute charging of the system and five-minute "bypass" stabilization, four samples at 3, 4, 7, and 11 liters passing through the filter paper were made. The sample pressures, flows, and temperatures were also recorded.

9.5 COMBUSTOR DATA REDUCTION

The punched paper tape from the DS10 (performance data) and DS8 (emission data) acquisition systems was interpreted and converted for transmission to the Lycoming IBM 360 computer system.

The data were inspected for errors, edited, and processed using the K136 Combustor Performance Data Reduction Program and K135 Emissions Data Reduction Program. The reflectance of the smoke deposit on the filter paper was measured with a McBeth Reflection Densitometer and processed using K134 Smoke Data Reduction Program.

The punched-cards output from each of the three programs were then combined in the predetermined format and shipped to Calspan Technology Products.

9.6 COMBUSTOR DATA

The combustor data (Appendix B) obtained during the rig test program were transmitted to Calspan for analysis.

10.0 ENGINE VERIFICATION TESTING

10.1 GENERAL

The engine test portion of the program was conducted on a standard ALF 502 Lycoming turbofan engine under varied uncontrolled inlet conditions to obtain emissions data over the full power range. Tests were run at seven power levels under seven different ambient conditions.

The installation of the engine was in accordance with Lycoming's normal procedures, and the engine carried the standard compliment of performance monitoring instrumentation in addition to the emissions measurement equipment. The test cell and facilities and operational procedures are described in detail in this section.

10.2 TEST FACILITIES

Eighteen engine test cells of various configurations are available at the Avco Lycoming Stratford facilities for sea-level testing of turboshaft, turboprop, turbojet, and turbofan engines both indoors and outdoors. One of the indoor facilities, the T13 in the Building 16 complex was used for this test. The test cell (a U-type configuration) is shown schematically in Figure 10-1 with the engine suspended from a Osmond thrust bed with a range of 0--10,000 pounds and an accuracy of ± 0.1% full scale. A bellmouth mounted to the engine inlet and pressure and temperature instrumentation located in the engine were used to determine engine performance.

The engine is connected to the various control and instrument systems illustrated in Figure 10-2.

The test cell fuel system uses fuels drawn from a 378,500 liter fuel drum. Sound attenuation equipment is installed within the intake and exhaust sections capable of passing 600 lb/sec of air with attenuation of 130 to 90 db outside the cell.

Up to 20 variables are displayed on a CRT just above the console. The display was updated every four seconds to provide real time monitoring of such parameters as thrust, ambient conditions, SFC, compressor pressure ratio, inlet airflow, and high-temperature turbine temperature.

The data acquisition sequence was initiated via keyboard control of the remotely located acquisition and computing system described in Section 8.

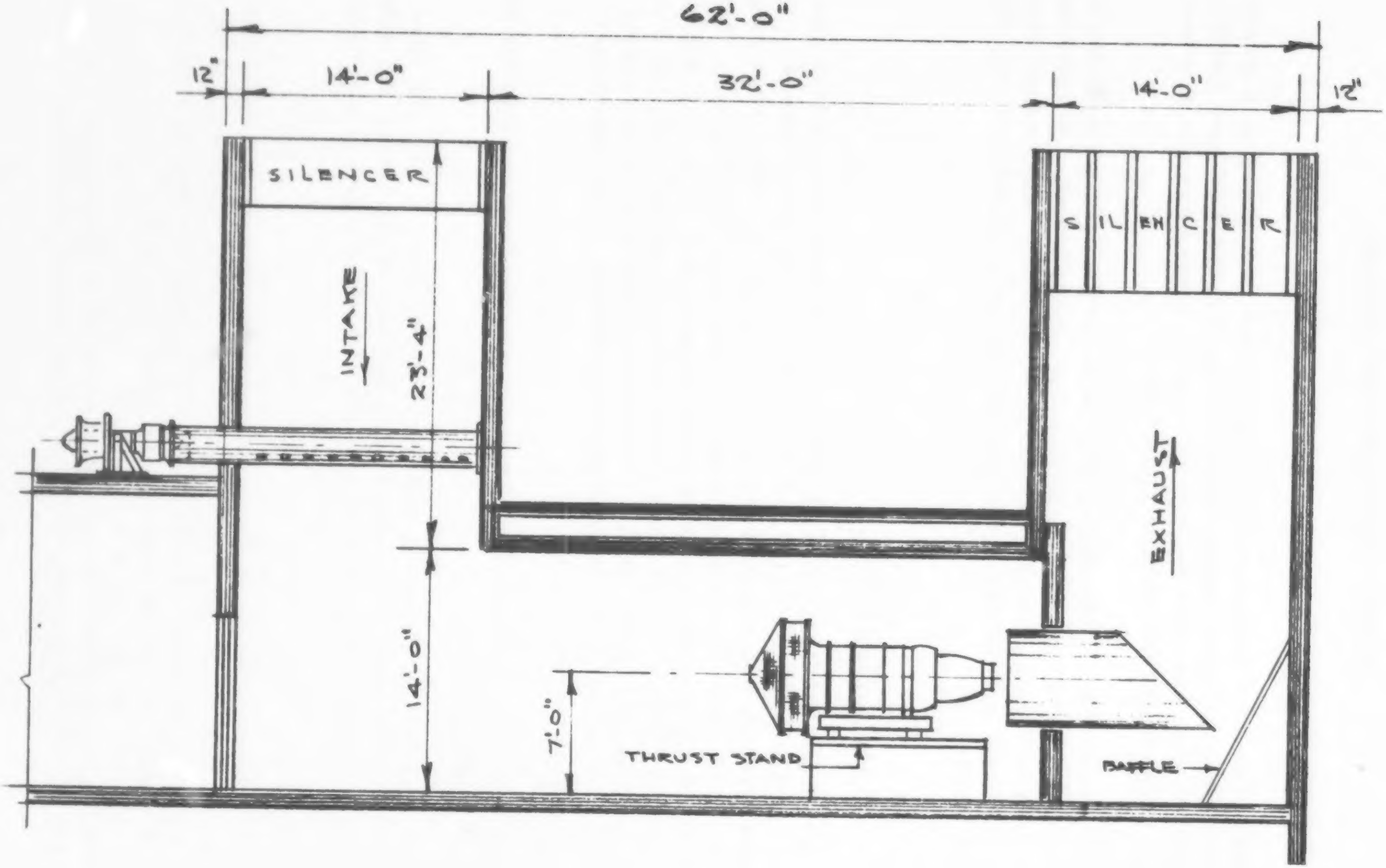

62'-0"
12"
14'-0"
32'-0"
14'-0"
12"
SILENCER
SILENCER
INTAKE
23'-4"
EXHAUST
14'-0"
7'-0"
THRUST STAND
BAFFLE

Figure 10-1. Test Cell 13 Schematic.

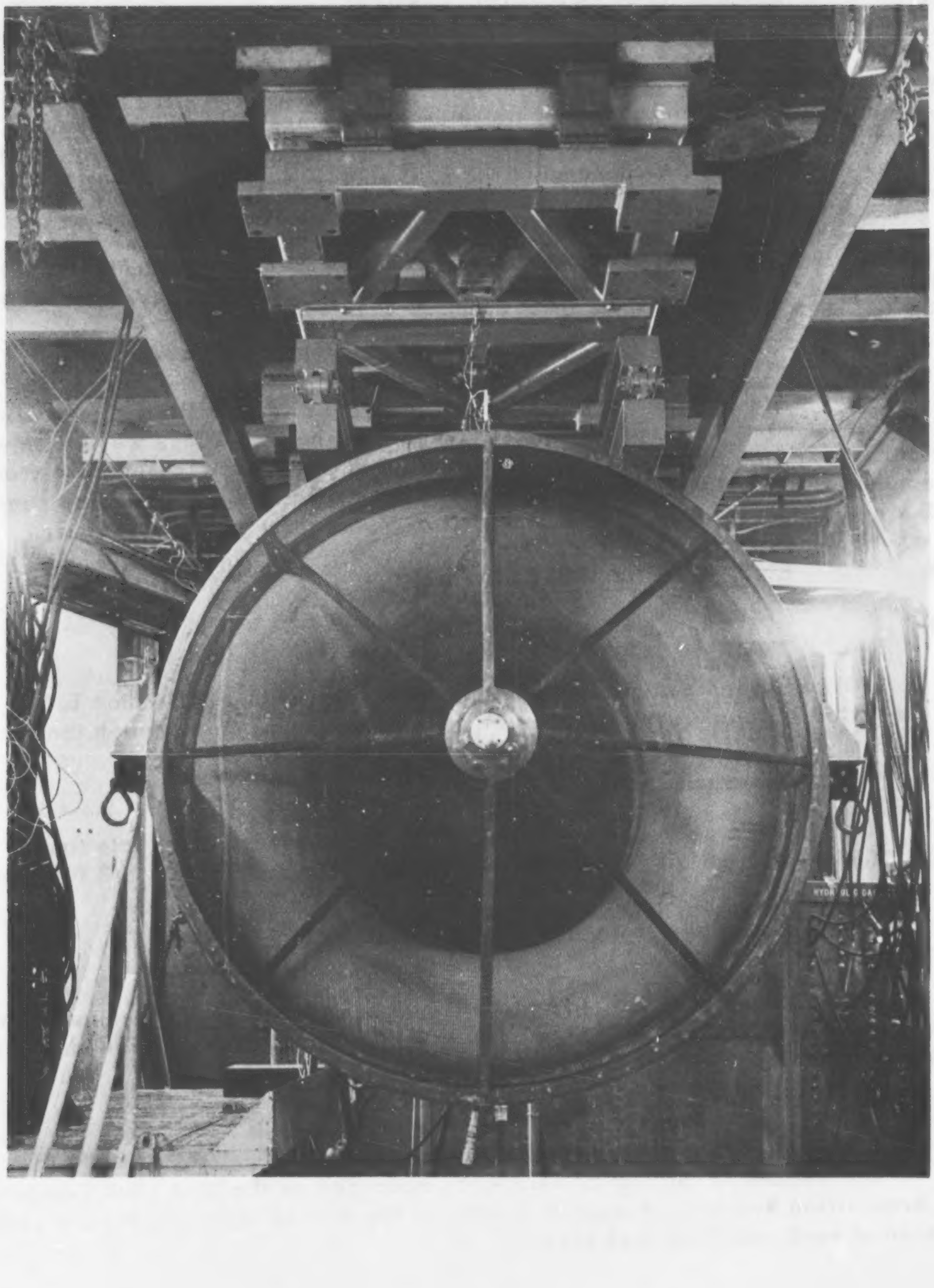

HYDRAULIC DATA

Figure 10-2. ALF 502 Engine Mounting.

10.3 ENGINE GAS SAMPLING SYSTEM

The gas sampling probe described in paragraph 8.3 was mounted to a supporting frame at the rear of the engine as shown in Figure 10-3. A 9.525 mm (0.375 in.) O.D. stainless steel heated line was connected to the probe and extended down to the base of the stand. A 18.3 meter (60 ft), 9.525 mm O.D. stainless steel heated line connected the 1.83 meter (6 ft) section with the emission system.

The two sections of sample line are independently controlled by Dekoron, Model 1660, temperature controllers with thermistor feedback. The thermistors are located at the end of the 1.83 meter section away from the sample probe and at the emission system end of the 18.3 meter section.

The stand was positioned so that the probe aligned with the centerline of the exhaust nozzle and aligned axially such that the probe legs were within 6.35 mm (0.25 in.) of the nozzle. Although the probe tended to separate from the engine, the nozzle remained within the probe shroud at all operating conditions. Fuel-air ratio correlation gave no indication of sample dilution by fan air.

10.4 ENGINE TEST PROCEDURES

10.4.1 Pre-Engine Test Checks

All of the instrument and system checks described in Section 8.0 (the Emission Measurement Technique) were performed prior to each test day.

10.4.2 Acquisition Sequence

Engine data were acquired in the following order: 1) taxi idle (out), 2) takeoff, 3) climb-out, 4) cruise 1, 5) cruise 2, 6) approach, 7) 1/2 idle, and 8) taxi idle (in).

10.4.3 Stabilization

Stabilization was determined by visual observation of the engine operating parameters at the console and the plotted emissions data. The emissions were required to remain unchanged for approximately five minutes.

10.4.4 Engine Performance Data Acquisition

The engine performance data were recorded on the IBM 1800 Computer Data Acquisition System. A sample listing of the data is shown in Figure 10-4. One scan at each condition was taken.

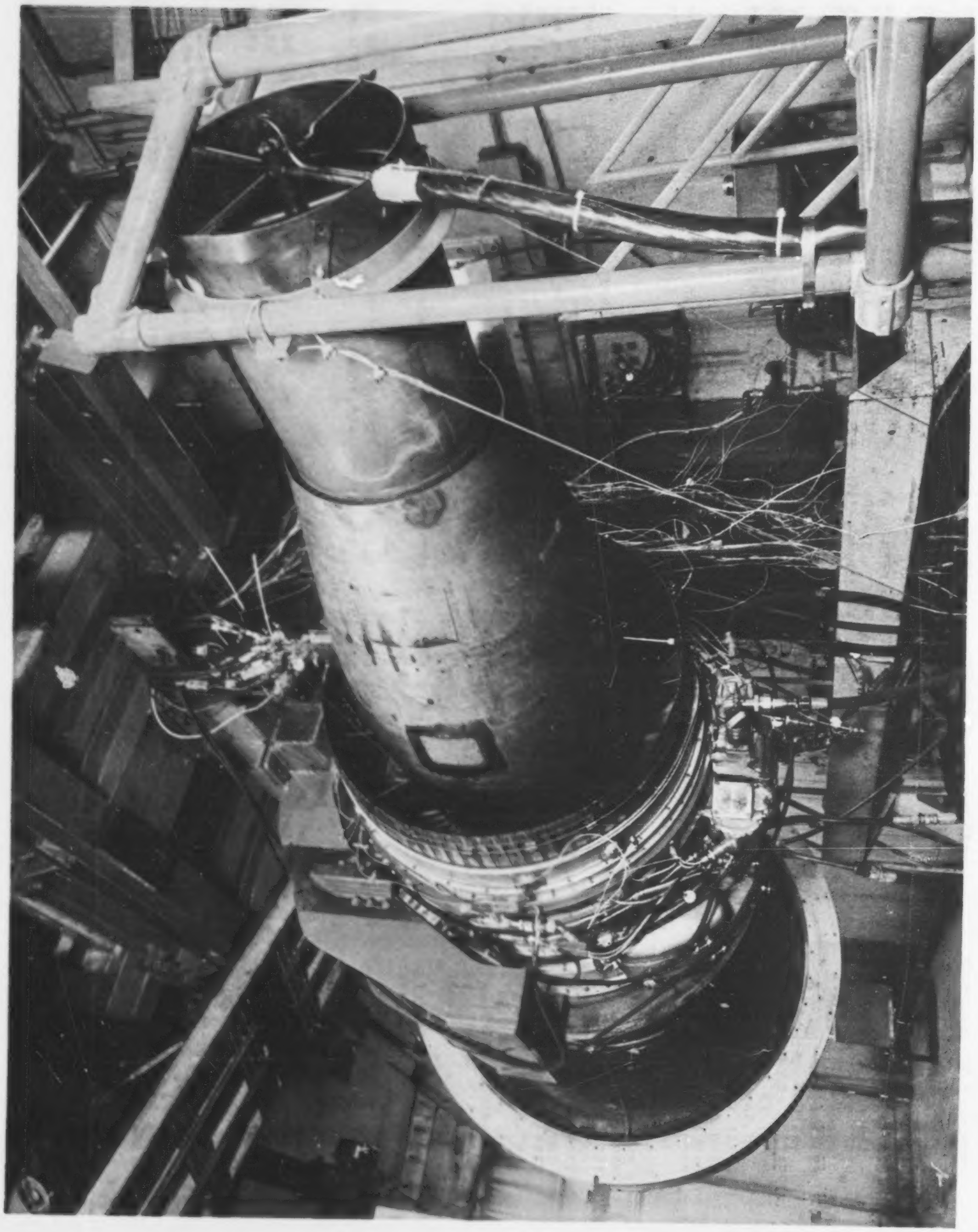
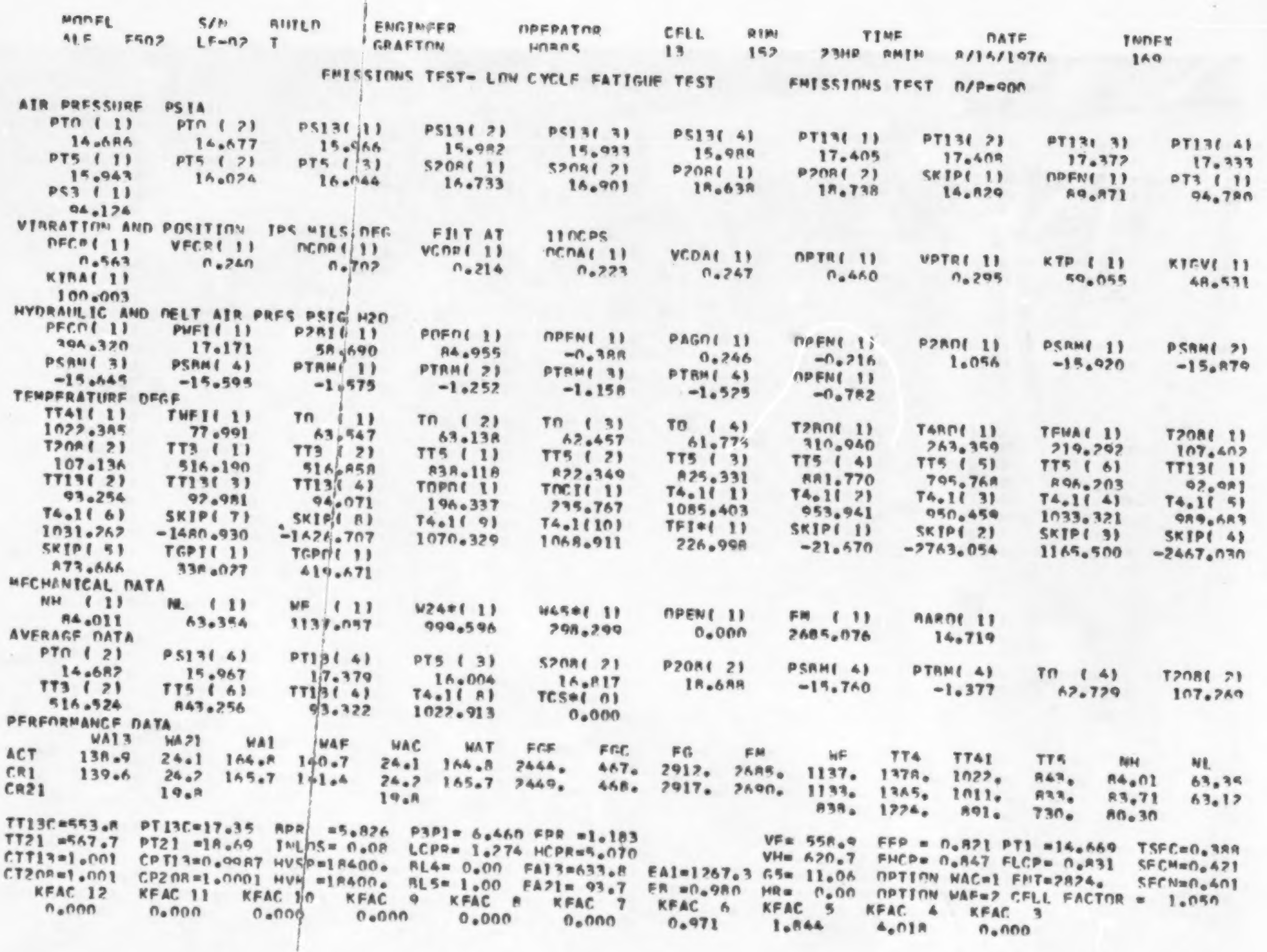


Figure 10-3. ALF 502 Gas Sample Probe Installation.



```
 MODEL        S/N     BUILD     ENGINEER      OPERATOR      CELL    RUN        TIME         DATE           INDEX
 ALF  502     LF-02   T         GRAFTON       HOBBS         13      152     23HR  8MIN   8/16/1976          169
                                EMISSIONS TEST- LOW CYCLE FATIGUE TEST          EMISSIONS TEST  D/P=900
AIR PRESSURE  PSIA
   PTO ( 1)    PTO ( 2)    PS13( 1)    PS13( 2)    PS13( 3)    PS13( 4)    PT13( 1)    PT13( 2)    PT13( 3)    PT13( 4)
    14.686      14.677      15.966      15.982      15.933      15.989      17.405      17.408      17.372      17.333
   PT5 ( 1)    PT5 ( 2)    PT5 ( 3)    S208( 1)    S208( 2)    P208( 1)    P208( 2)    SKIP( 1)    OPEN( 1)    PT3 ( 1)
    15.943      16.024      16.044      16.733      16.901      18.638      18.738      14.829      89.871      94.780
   PS3 ( 1)
    94.124
VIBRATION AND POSITION  IPS MILS DEG    FILT AT     110CPS
   DECR( 1)    VFCR( 1)    DCOR( 1)    VCOR( 1)    DCDA( 1)    VCDA( 1)    DPTR( 1)    VPTR( 1)    KTP ( 1)    KIGV( 1)
     0.563       0.240       0.702       0.214       0.223       0.247       0.460       0.295      59.055      48.531
   KIBA( 1)
   100.003
HYDRAULIC AND DELT AIR PRES PSIG H2O
   PECO( 1)    PWFI( 1)    P28I( 1)    POFO( 1)    OPEN( 1)    PAGO( 1)    OPEN( 1)    P28O( 1)    PSAM( 1)    PSAM( 2)
   396.320      17.171      58.690      84.955      -0.388       0.246      -0.216       1.056     -15.920     -15.879
   PSAM( 3)    PSAM( 4)    PTAM( 1)    PTAM( 2)    PTAM( 3)    PTAM( 4)    OPEN( 1)
   -15.645     -15.595      -1.575      -1.252      -1.158      -1.525      -0.782
TEMPERATURE DEGF
   TT41( 1)    TWFI( 1)    TO  ( 1)    TO  ( 2)    TO  ( 3)    TO  ( 4)    T28O( 1)    T48O( 1)    TEWA( 1)    T208( 1)
  1022.385      77.991      63.547      63.138      62.457      61.774     310.940     263.359     219.292     107.402
   T208( 2)    TT3 ( 1)    TT3 ( 2)    TT5 ( 1)    TT5 ( 2)    TT5 ( 3)    TT5 ( 4)    TT5 ( 5)    TT5 ( 6)    TT13( 1)
   107.136     516.190     516.858     838.118     822.349     825.331     881.770     795.768     896.203      92.981
   TT13( 2)    TT13( 3)    TT13( 4)    TOPO( 1)    TOCI( 1)    T4.1( 1)    T4.1( 2)    T4.1( 3)    T4.1( 4)    T4.1( 5)
    93.254      92.981      94.071     196.337     235.767    1085.403     953.941     950.459    1033.321     989.683
   T4.1( 6)    SKIP( 7)    SKIP( 8)    T4.1( 9)    T4.1(10)    TFI*( 1)    SKIP( 1)    SKIP( 2)    SKIP( 3)    SKIP( 4)
  1031.262   -1480.930   -1626.707    1070.329    1068.911     226.998     -21.670   -2763.054    1165.500   -2467.030
   SKIP( 5)    TGPI( 1)    TGPO( 1)
   873.666     338.027     419.671
MECHANICAL DATA
   NH  ( 1)    NL  ( 1)    WF  ( 1)    W24*( 1)    W45*( 1)    OPEN( 1)    FM  ( 1)    BARO( 1)
    84.011      63.354    1137.057     999.596     298.299       0.000    2685.076      14.719
AVERAGE DATA
   PTO ( 2)    PS13( 4)    PT13( 4)    PT5 ( 3)    S208( 2)    P208( 2)    PSAM( 4)    PTAM( 4)    TO  ( 4)    T208( 2)
    14.682      15.967      17.379      16.004      16.817      18.688     -15.760      -1.377      62.729     107.269
   TT3 ( 2)    TT5 ( 6)    TT13( 4)    T4.1( 8)    TCS*( 0)
   516.524     843.256      93.322    1022.913       0.000
PERFORMANCE DATA
        WA13    WA21     WA1     WAF     WAC     WAT    FGF    FGC     FG     FM       WF     TT4    TT41     TT5      NH      NL
ACT    138.9    24.1   164.8   140.7    24.1   164.8  2444.   467.  2912.  2685.    1137.   1378.   1022.    843.   84.01   63.35
CR1    139.6    24.2   165.7   141.4    24.2   165.7  2449.   468.  2917.  2690.    1133.   1365.   1011.    833.   83.71   63.12
CR21            19.8                    19.8                                        838.   1224.    891.    730.   80.30

TT13C=553.8  PT13C=17.35  BPR  =5.826  P3P1= 6.460 FPR =1.183               VF= 558.9  FFP = 0.821 PT1 =14.669  TSFC=0.388
TT21 =567.7  PT21 =18.69  INLOS= 0.08  LCPR= 1.274 HCPR=5.070               VH= 620.7  FHCP= 0.847 FLCP= 0.831  SFCM=0.421
CTT13=1.001  CPT13=0.9987 HVSP=18400.  BL4= 0.00  FA13=633.8  EA1=1267.3 G5= 11.06  OPTION WAC=1 FNT=2824.   SFCN=0.401
CT208=1.001  CP208=1.0001 HVH =18400.  BL5= 1.00  FA21= 93.7  ER =0.980  HR=  0.00  OPTION WAF=2 CELL FACTOR =  1.050
  KFAC 12     KFAC 11     KFAC 10     KFAC  9     KFAC  8     KFAC  7     KFAC  6     KFAC  5     KFAC  4     KFAC  3
   0.000       0.000       0.000       0.000       0.000       0.000       0.971       1.844       4.018       0.000
```

Figure 10-4. Engine Performance Data Listing - Sample.

10.4.5 Emissions Data Acquisition

The emissions data - including hydrocarbon, carbon monoxide, carbon dioxide, oxides of nitrogen, and smoke - were measured using the DS18 Portable Gaseous Emission and DS16C Portable Smoke Measurement System, respectively. Both systems are described in Section 8.0. The signals from the emissions instruments were recorded on the DS8 Portable Digital Data Acquisition System also described in Section 8.0. Calibration of each instrument was digitally recorded at the required intervals and checked for shifts in the zero and span of less than 2 percent as compared with the previous calibration.

Four scans of the data were recorded at 15-second intervals: two with the NO_x analyzer in the "NO" mode, and two while in the "NO_x" mode. Each scan consisted of recording the output of each of the four instruments, the pressure and temperature of the sample entering the sensor, and the instrument range being used. Each data point was taken within one hour of the last instrument calibration.

The emission values were converted to engineering units and used to compute the fuel-air ratio for comparison with the measured value from the IBM 1800 performance data.

The emission system was switched to the "smoke sample" mode for redirecting the sample to the DS16C smoke meter. After the required one-minute system charging and five-minute "bypass" stabilization, the four samples at 3, 4, 7, and 11 liters through the filter paper were made.

10.5 ENGINE DATA REDUCTION

The punched paper tape from the DS8 Digital Data Acquisition System was interpreted by a photoreader converter system and transmitted to Lycoming's IBM 360 computer system.

The emission data were inspected for errors, edited, and processed, using the K135 Emission Data Reduction Program. The reflectance of the smoke deposit on the filter paper was measured with the McBeth model RD-400 reflection densitometer and processed using K134 Smoke Data Reduction Program. The punch-cards output from each was combined with the engine performance data in the predetermined format and prepared for shipment to Calspan Technology Products. The indicated core airflow has been adjusted for the bleed air (13%) at idle and 1 1/2 idle and overboard leakage (2%) at all conditions. The turbine cooling air, however, has not been deducted so as to represent the airflow seen by the gas sample probe.

10.6 ENGINE DATA

The data (Appendix C) obtained from the engine test program was transmitted to Calspan Technology Products for analysis.

11.0 DISCUSSION

11.1 GENERAL

The purpose of the testing accomplished under this program was to provide combustor test rig and full engine emissions data for later analysis and correlation. The engine selected was a Lycoming ALF 502 turbofan in the T-1 class category. The testing accomplished provides a wide variation of operational and ambient conditions which form a substantial data base for subsequent development of ambient correction factors.

The data accumulated from this testing has been reduced in the form of plots showing general effects and trends of conditions on emission levels. These plots are presented herein.

11.2 FUEL-AIR RATIO CORRELATION

The criterion used for sample representativeness was the correlation of emission fuel-air ratio with measured fuel and airflow.

The combustor fuel-air ratio correlation averaged less than 2 percent at all simulated power conditions.

The engine and rig fuel-air ratio correlation was acceptable at all power levels. The average percentage differences between the measured and emission (gas analysis) value $\left(\frac{F/A_{meas} - F/A_{G.A.}}{F/A_{G.A.}}\right)$ were as follows:

Power Level	Average Diff. (%) Engine Test	Average Diff. (%) Rig Test
Taxi Idle (out)	2.7	1.26
Takeoff	5.4	- - -
Climbout	5.0	- - -
Cruise No. 2	1.1	- - -
Cruise No. 1	0.9	- - -
Approach	1.1	1.28
1 1/2 Idle	3.5	1.25
Taxi Idle (in)	2.0	- - -

The better correlation in the rig testing is due to the more precise measurement of combustor airflow than is possible in the full engine.

11.3 HUMIDITY CORRELATION

The two humidity measurement methods used during the combustor rig test consistently agreed over the range of operation.

Selected voltage values from the two dew point meters (ambient air and rig air) were input in tabular form of voltage versus degree Centigrade to the computer program.

The humidity (R) at each station was computed from its respective temperature (T, °F) using Equation (1). The polynomial coefficients for the partial pressure operation was developed using a calculator program (Reference 3) by inputing temperatures and associated values of vapor pressure over the expected operating range (0°-100°F) from the table of water vapor pressures presented in Reference 4.

$$R \text{ (Grains of } H_2O\text{/lb of dry air)} = \frac{0.62192\ Pv}{P_{BARO} - Pv} \times 7000 \quad (1)$$

where Pv (Partial Press.) - $4.58062914 + 3.327097623E\text{-}1T +$
$1.077633396E\text{-}2\ T^2 + 1.987127117E\text{-}4\ T^3 +$
$2.102836053E\text{-}6\ T^4 + 2.03975894E\text{-}8\ T^5$

and

$$P_{BARO} \text{ (mm Hg)} = P_{BARO} \text{ (PSIA)} \times \frac{760}{14.696}$$

The frequency output of the turbine elements recorded by the data acquisition system was also converted to pounds per hour of water by a table look-up routine.

The water content at the rig inlet was then determined by Equation 2.

$$R_{RIG} \text{ (Grains of } H_2O\text{/lb of dry air)} = R_{AIR} + \left(\frac{W_W}{W_a}\right) \times 7000 \quad (2)$$

where W_W = water flow (pph)

and W_a = air flow (pph)

---

(3) HP 9820A Math Pac, P/N 09820-70000, Curve Fitting by Chebyshev Polynomials, Pg. 125-130

(4) Measurements and Data, Vol. 9 No. 5, September/October 1975, Table 4, Pg. C5-C9

The average difference between the two measurement methods at each level of operation was as follows:

Nominal Humidity Level (Grains)	Average Difference (Grains)
25	1.4
35	1.3
52.5	1.7
70	2.6
105	3.4
175	4.7

11.4 ENGINE/TEST RIG EMISSIONS EQUIVALENCE

11.4.1 General

The engine verification testing appeared to give reasonably good comparison with corrected data generated in the rig test portion of the program. Since the engine test portion was run under uncontrolled ambient conditions, direct simulation of all parameters was not expected, nor achieved, between the rig and engine tests.

In order to compare the equivalence of the engine and rig tests, the rig and engine points most closely approximating standard-day conditions at the three common tested power levels have been tabulated. Combustor inlet conditions were used as the criteria for selecting the closest equivalent performance points, since the resulting emissions are dependent on these conditions. Table 11-1 presents these combustor performance comparisons and the resulting emission indexes. Examination of this table shows that there is good equivalence between most of the combustor performance parameters (independent variables) and emissions parameters (dependent variables). Some parameters, however, do not show direct correlation as presented and are discussed below. The differences in the dependent variable correlations appear due to lack of exact equivalence between the independent variables.

11.4.2 Performance Parameters (Independent Variables)

Combustor Inlet Pressure, P_3

Equivalence between the engine and rig is within the expected engine variability when compared with the engine design parameters.

Combustor Inlet Temperature, T_3

The comparison of temperature is good at all three power settings.

TABLE 11-1. COMPARISON OF ENGINE AND RIG TESTING

Parameters	IDLE			1.5 x IDLE			APPROACH		
	Rig	Engine	Diff	Rig	Engine	Diff	Rig	Engine	Diff
Test Point	001145	281117		002145	282207		003144	283307	
P_3 (psia)	35.2	32.4	+2.8	40.2	39.9	+0.3	75.2	73.2	+2.0
T_3 (^oR)	684	691	-7	746	740	+6	899	905	-6
H (gr H_2O/Air)	42.3	63.3	-21.0	44.0	63.3	-19.3	44.9	62.5	-17.6
W_f (pph)	349	365	-16	416	442	-26	804	778	+26
$\dot{W}_a$ (meas) pps	7.3	8.1	-0.8	10.7	10.1	+0.6	17.5	17.3	+0.2
F/A (measured)	.0133	.0125	+.0008	.0108	.0121	-.0013	.0128	.0125	+.0003
HC E.I.	5.46	5.23	+0.23	6.94	3.19	+3.75	0.78	0.48	+0.30
CO E. I.	39.3	42.5	-3.2	46.6	33.7	+12.9	15.0	10.8	+4.2
NO_x E. I.	2.9	3.0	-0.1	3.1	3.4	-0.3	5.1	5.8	-0.7

Absolute Humidity, H

A wide difference between engine and rig humidities exists because no equivalent engine test points were run.

Fuel Flow W_f

Fuel flows compare well between engine and rig points within expected engine variability limits.

Combustor Airflow, W_a

Airflows compare very closely at the approach conditions, but the idle and 1.5 x idle points are different in the engine and rig by between 5 to 10 percent. This variation is due to a combination of engine variability from nominal values and problems encountered in accurately extrapolating the low-power engine operating conditions from computer deck printouts of the higher power points. Engine variability (including measurement error tolerances) can account for up to 4 percent of the total difference with extrapolation of the rig points accounting for the remainder.

Combustor Fuel-Air Ratio, F/A

Since fuel-air ratio is a direct function of air and fuel flows, the variability between engine and rig points is dependent on the same causes as explained above. As with the airflow, the fuel-air ratio shows excellent agreement between rig and engine at the approach conditions, less at idle, and a significant difference at the 1.5 x idle points.

11.4.3 Emissions Parameters (Dependent Variables)

Figure 11-1 shows CO, HC, and NO_x emission indexes for rig and engine tests as a function of power level. Corrections to the CO and HC indexes shown at idle and 1.5 x idle account for the significant difference in fuel-air ratio between rig and engine test points. These are estimated corrections based on the trends exhibited during the rig testing results shown in Figures 11-11, 11-12, 11-14, and 11-15 presented in paragraph 11.5.

Taking into account the fuel-air ratio estimated corrections, reasonably good correspondence is evident between engine and rig testing. The exact degree of correspondence can be shown only when correction factors for all the variables are developed as a result of final data analysis from this and other similar programs.

Specific comments on the emission index correlations are discussed in the following paragraphs.

Hydrocarbon Emissions Index, HC E.I.

The HC E.I. shows good consistency between rig and engine at approach and idle with a difference in both cases under 0.3 in E. I. number.

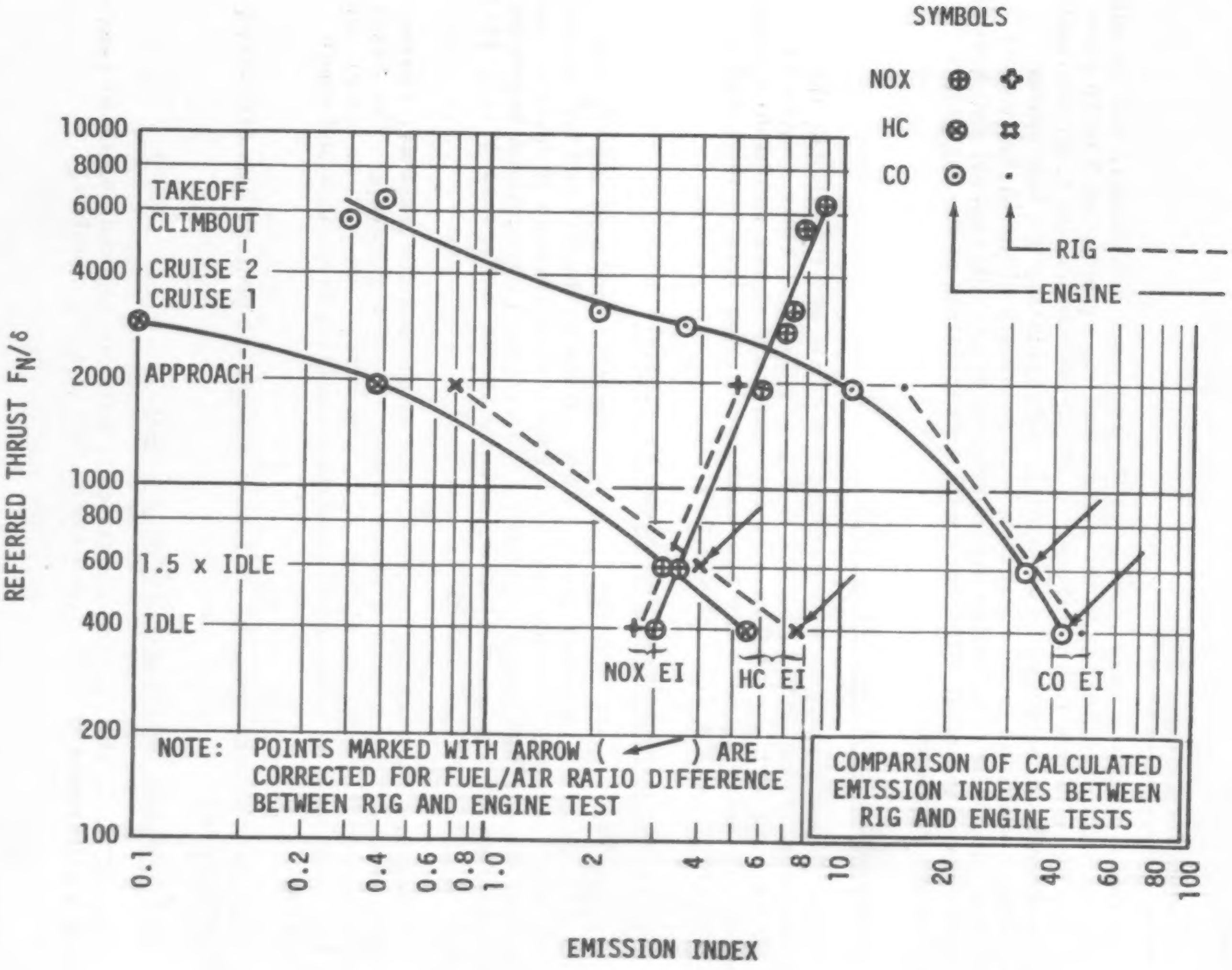


Figure 11-1. Comparison of Calculated Emission Indexes Between Rig and Engine Tests.

There is, however, a variation of 3.75 in E. I. numbers between the rig and engine at 1.5 x idle. This is not an unexpectedly larger variation for the corresponding difference in fuel-air ratios between engine (F/A = 0.0121) and rig (F/A = 0.0108), since rig data showed similar trend as evidenced by Figure 11-12.

Carbon Monoxide Emissions Index, CO E. I.

The CO E. I. shows good consistency at idle, but 1.5 x idle and approach comparisons show differences in E. I. number of 12.9 and 4.2, respectively. As with the HC E.I., the 1.5 x idle comparison between rig and engine is consistent with that expected from rig data for the difference in fuel-air ratios as indicated in Figure 11-16. The high value of CO E. I. recorded at rig approach conditions is slightly outside the range expected based upon rig test correlation with fuel-air ratio as presented again in Figure 11-16.

Oxides of Nitrogen Emission Index, NO_x E. I.

The rig NO_x levels, although lower than the corresponding engine data due to differencies in conditions, were of consistent magnitude with engine levels, and no attempt was made for further correlation.

Smoke Emissions

The smoke levels at the three lower power conditions were too low for an effective assessment of the relationship between rig and engine values.

11.5 DATA PLOTS

Figures 11-2 through 11-31 consist of uncorrected data referenced to parameters affecting the emission levels or pertinent relationships of one component to the other. No curve fitting techniques were used.

The figures include data from the combustor rig test at each simulated power level, test condition, and engine emission data. The test condition nomenclature on each plot refer to the engine and rig ambient conditions indicated in Tables 2-2 and 2-3 respectively.

Figures 11-2 through 11-4 show the rig data correlation of CO Emission Index (E. I.) to HC Emission Index at each test condition for idle, 1.5 x idle, and approach.

Figures 11-5 through 11-10 show the rig test data correlation of CO and HC Emission Index to T_{t3} for each test condition for the three power levels.

Figures 11-11 through 11-19 indicate the relation of each rig gaseous emission component to the fuel-air ratio.

Figures 11-20 through 11-22 correlate the rig NO_x Emission Index to the combustor inlet temperature (T_3) at each rig test power level.

Figures 11-23 through 11-27 show the CO - HC Emission Index relationship, fuel-air ratio effect (one each component), and T3 on the NO_x Emission Index for the seven engine tests.

Figures 11-28 through 11-31 show each exhaust constituent measured, including smoke number for the seven engine tests as a function of referred thrust.

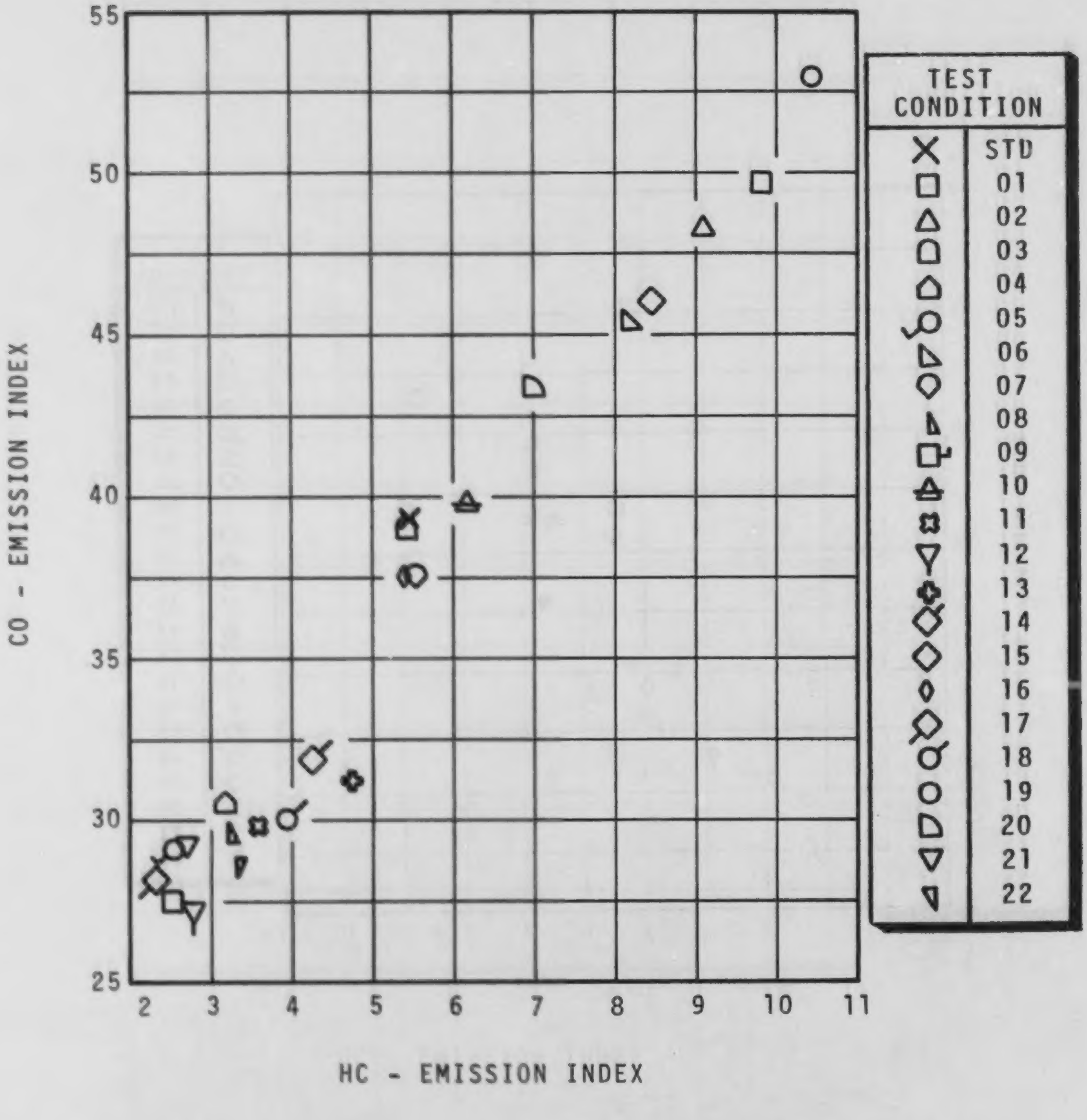


Figure 11-2. CO Emission Index Versus HC Emission Index, Rig Test - Idle.

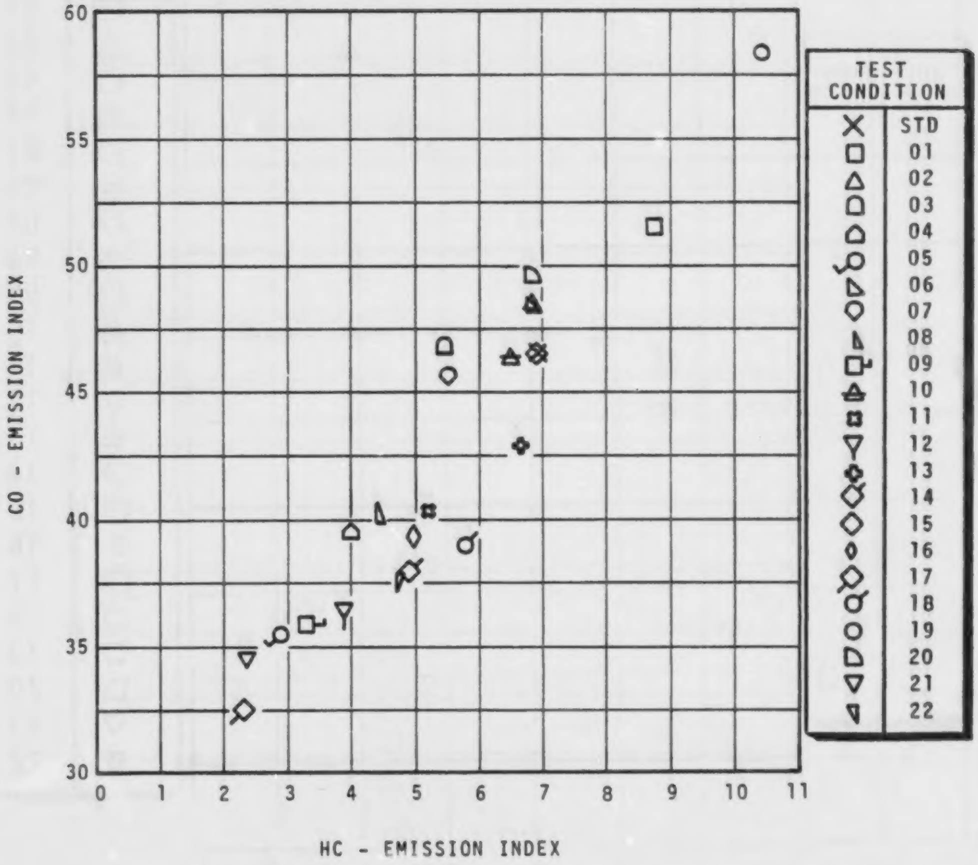


Figure 11-3. CO Emission Index Versus HC Emission Index, Rig Test - 1.5 x Idle

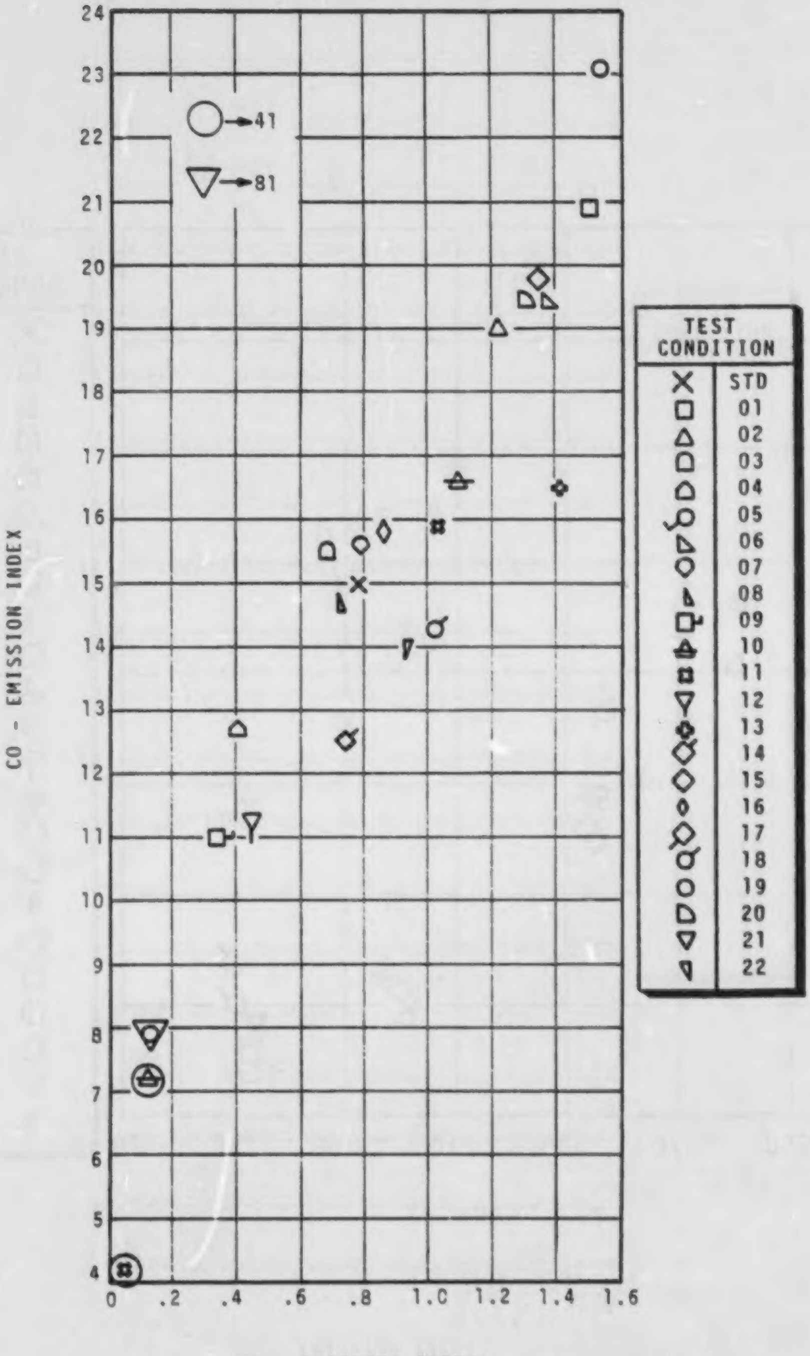


Figure 11-4. CO Emission Index Versus HC Emission Index, Rig Test - Approach.

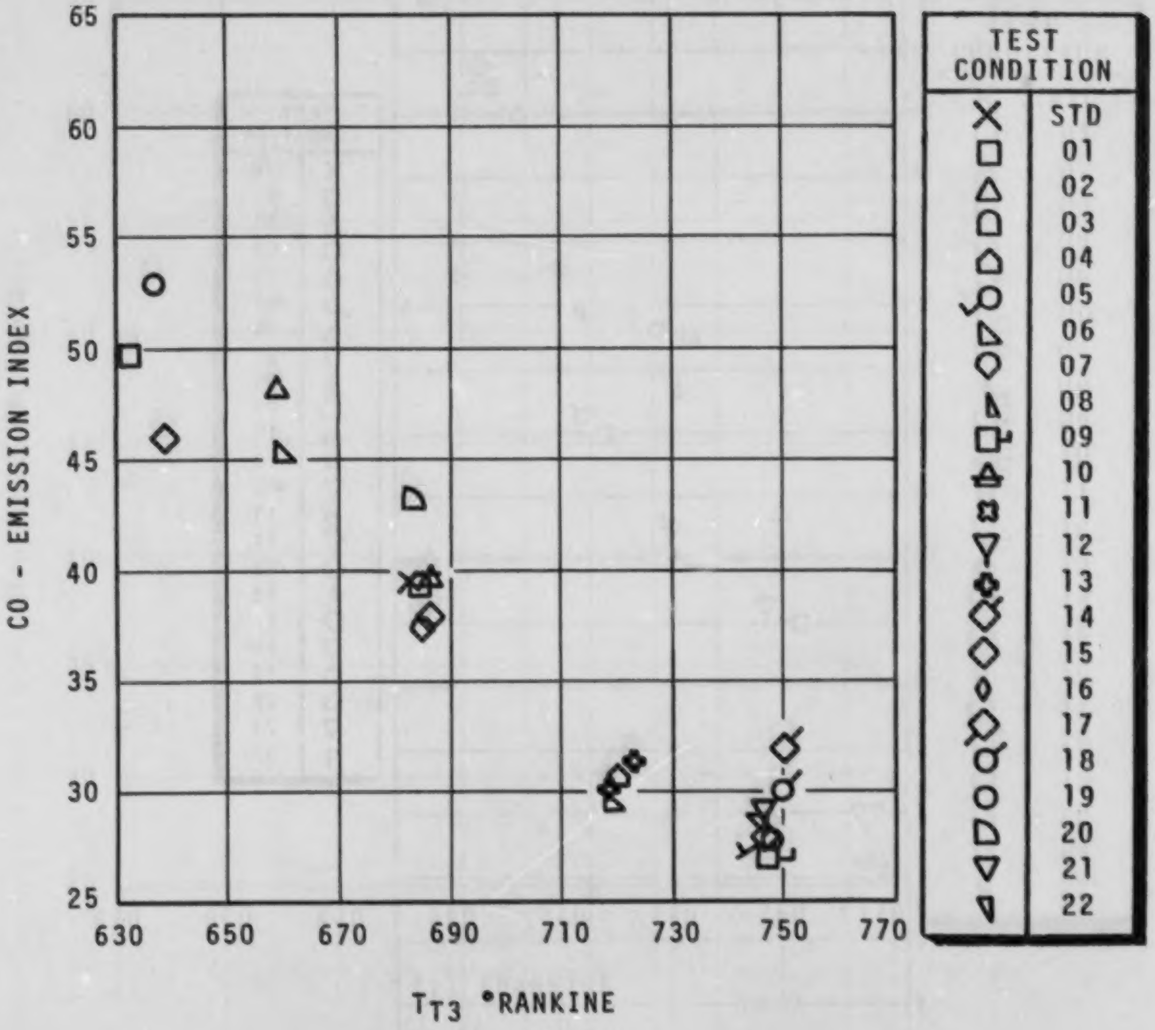


Figure 11-5. CO Emission Index Versus Tt3 Rig Test, Idle.

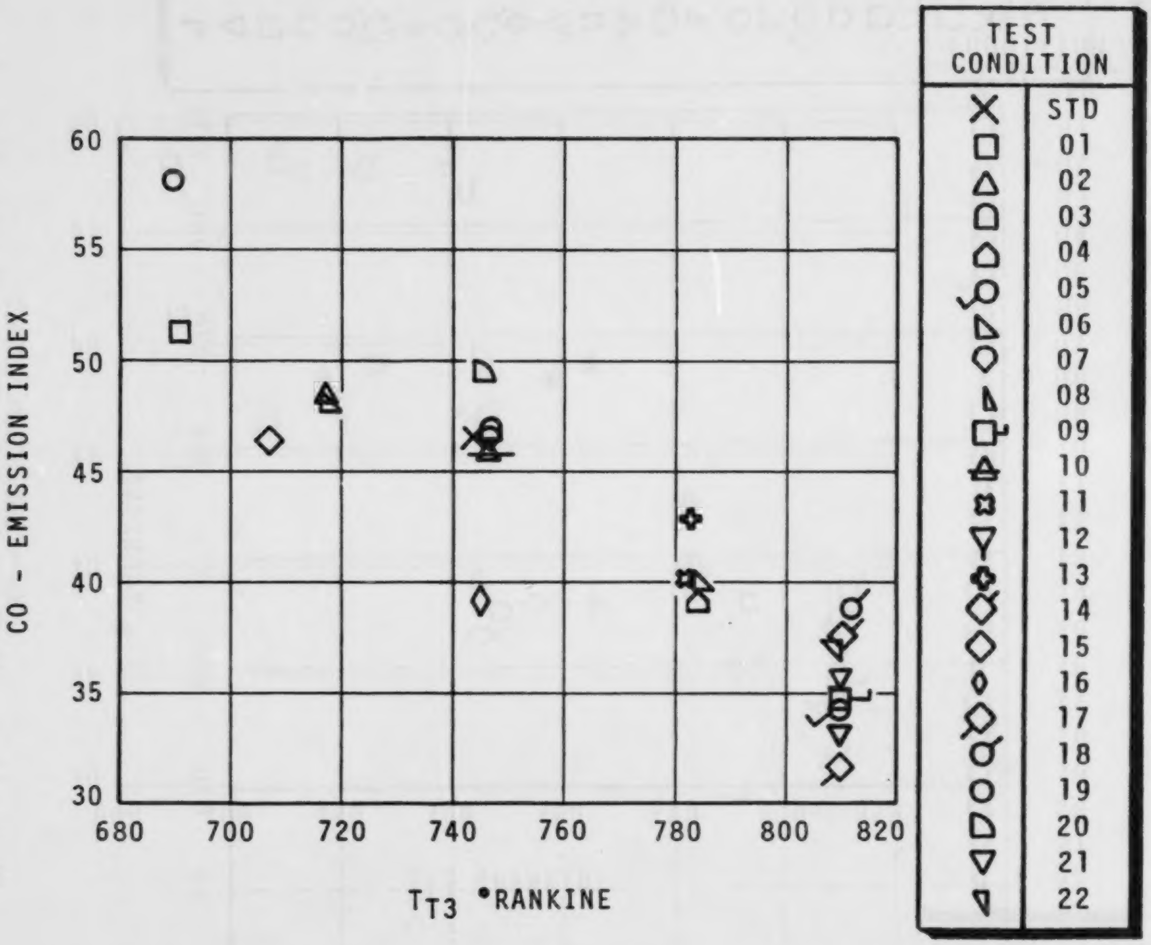


Figure 11-6. CO Emission Index Versus T_{t3} Rig Test, 1.5 x Idle.

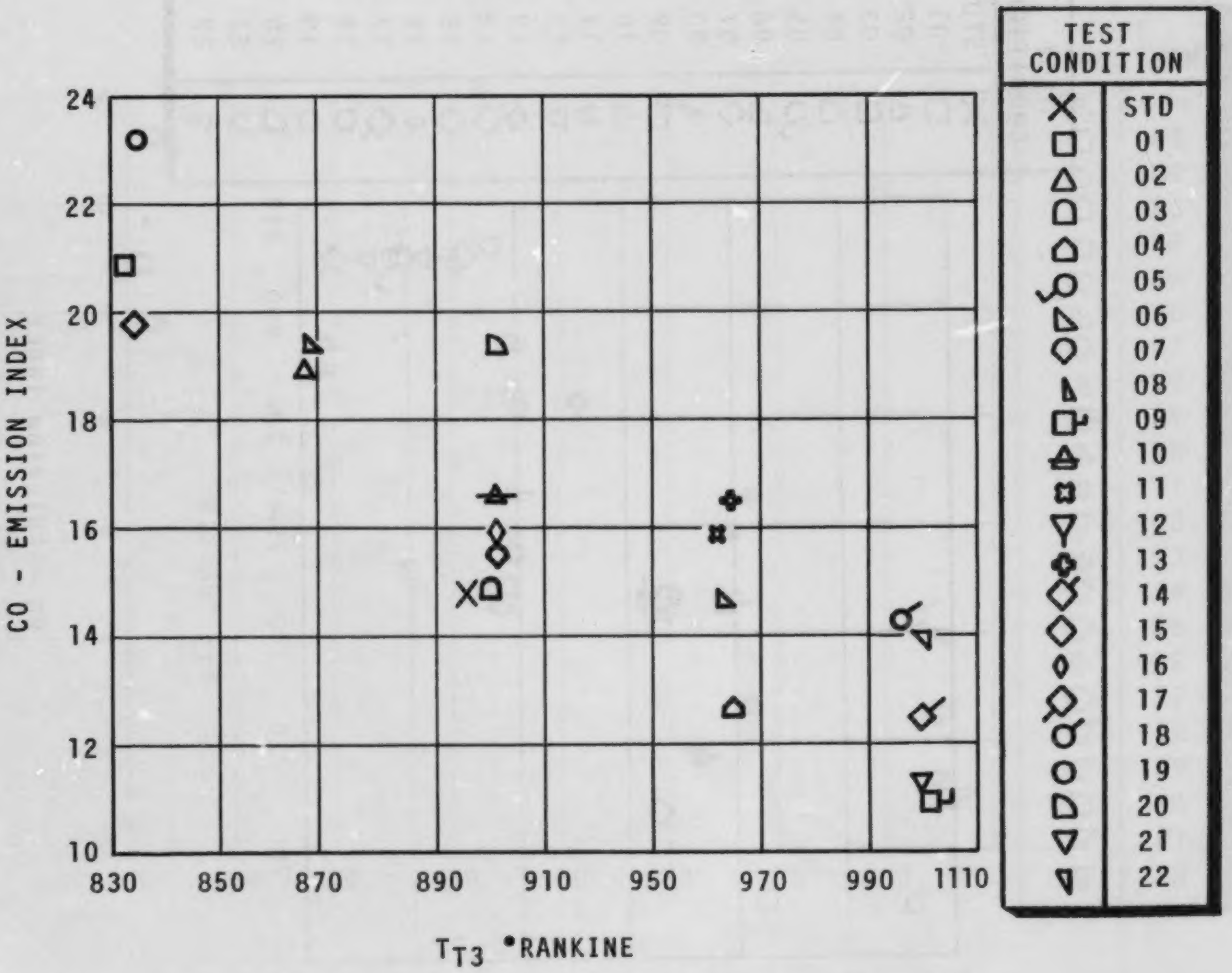


Figure 11-7. CO Emission Index Versus T_{t3} Rig Test, Approach.

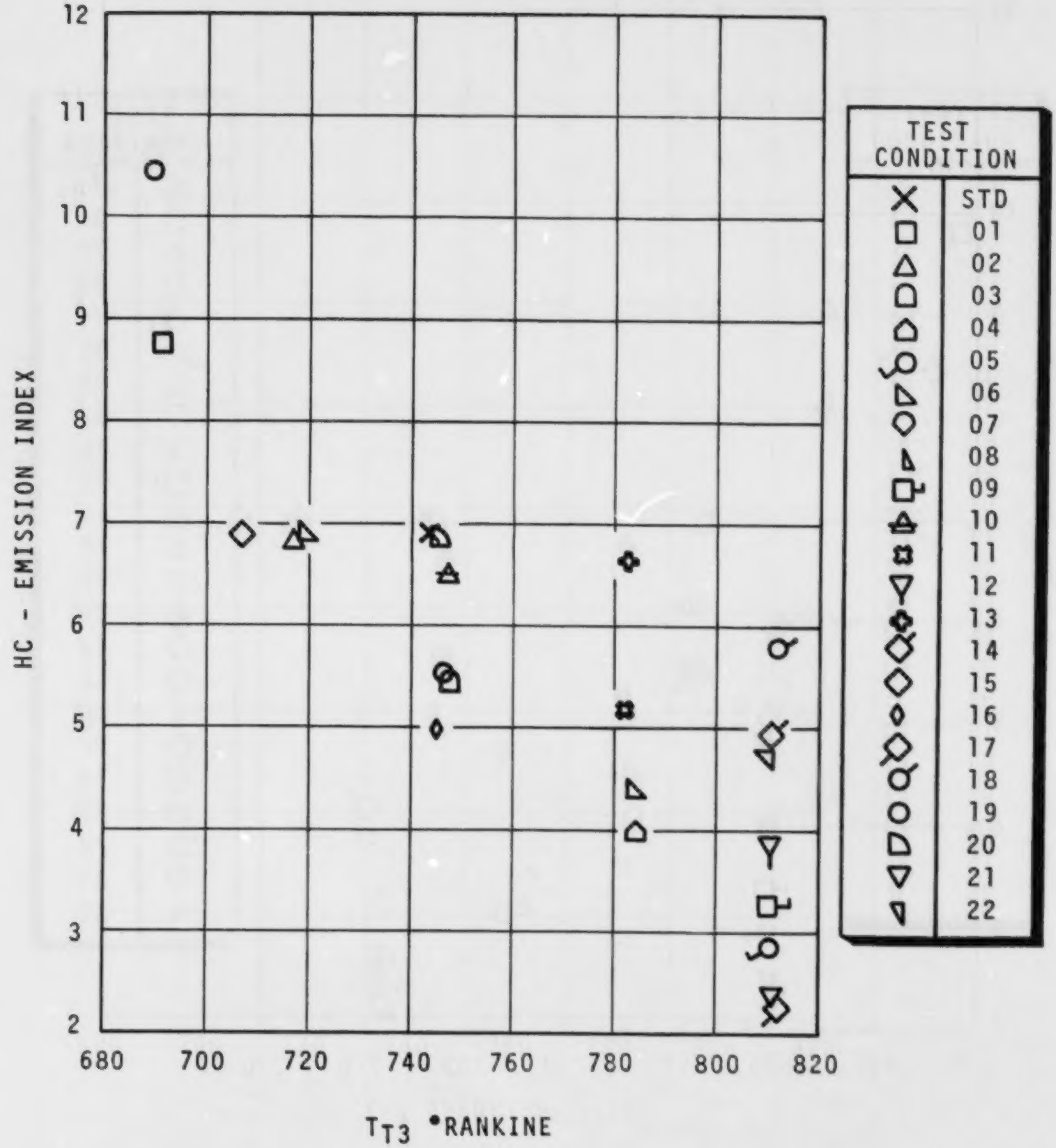


Figure 11-8. HC Emission Index Versus T_{t3} Rig Test, Idle.

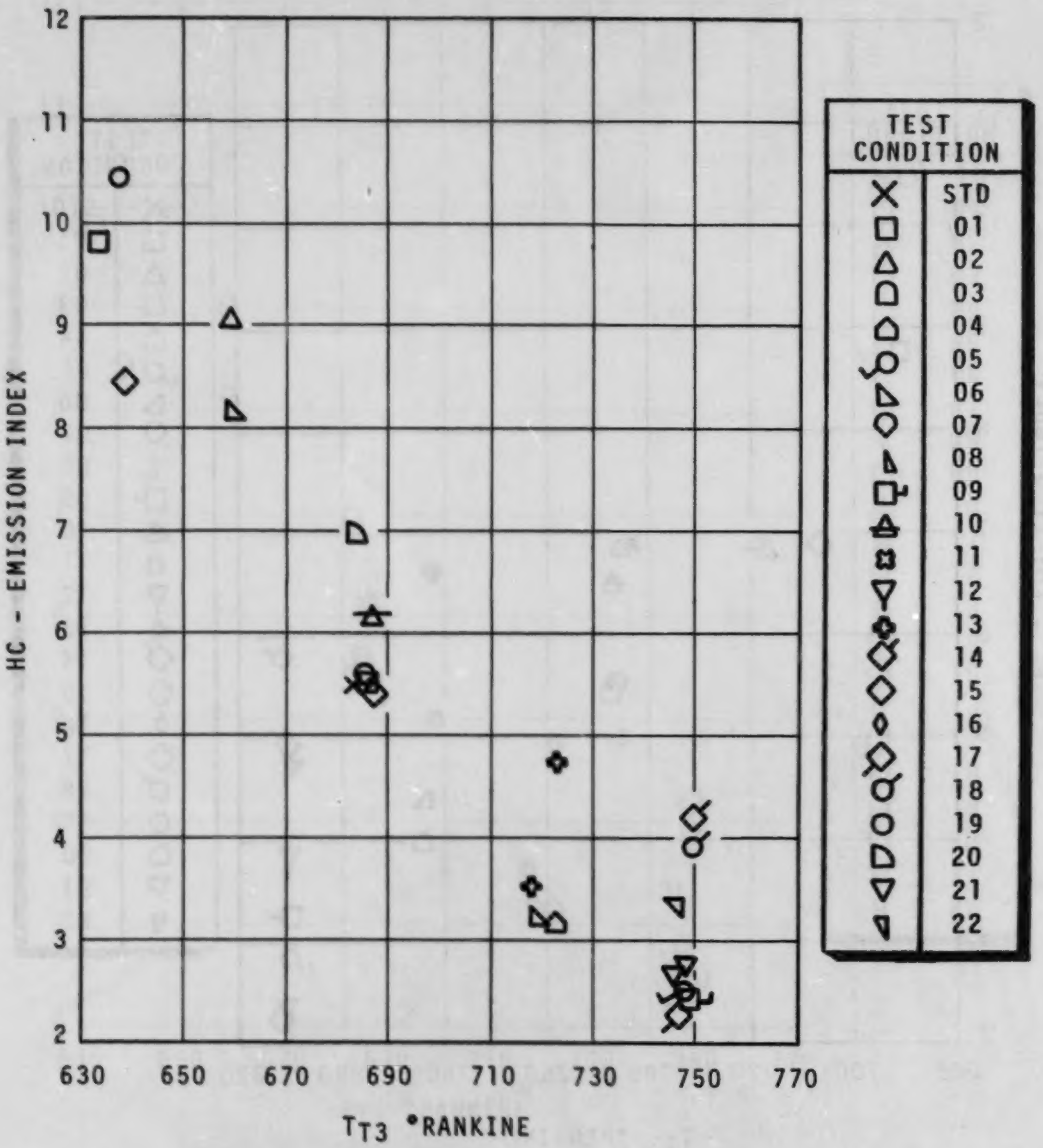


Figure 11-9. HC Emission Index Versus T_{t3} Rig Test, 1.5 x Idle.

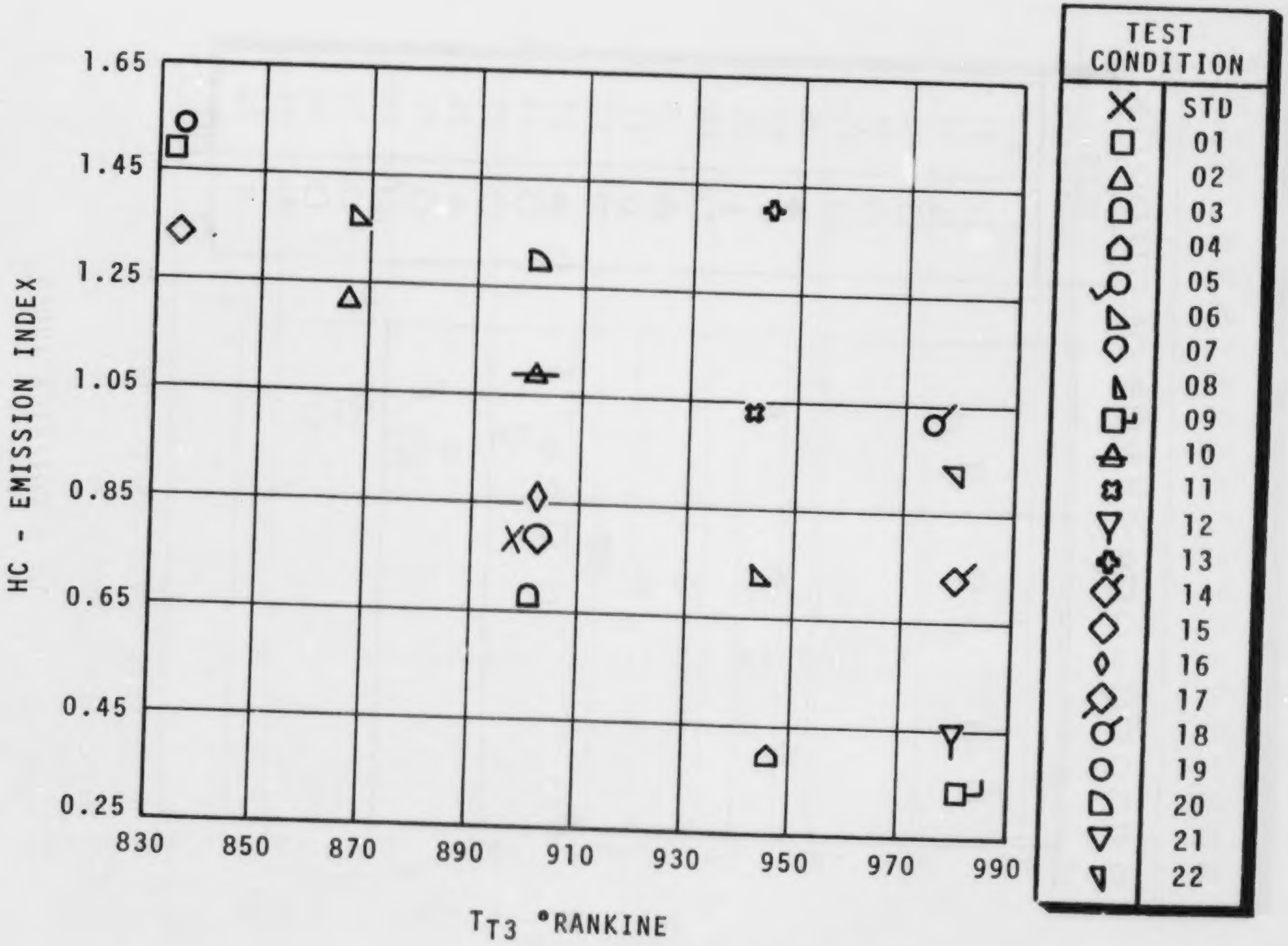


Figure 11-10. HC Emission Index Versus T_{t3} Rig Test, Approach.

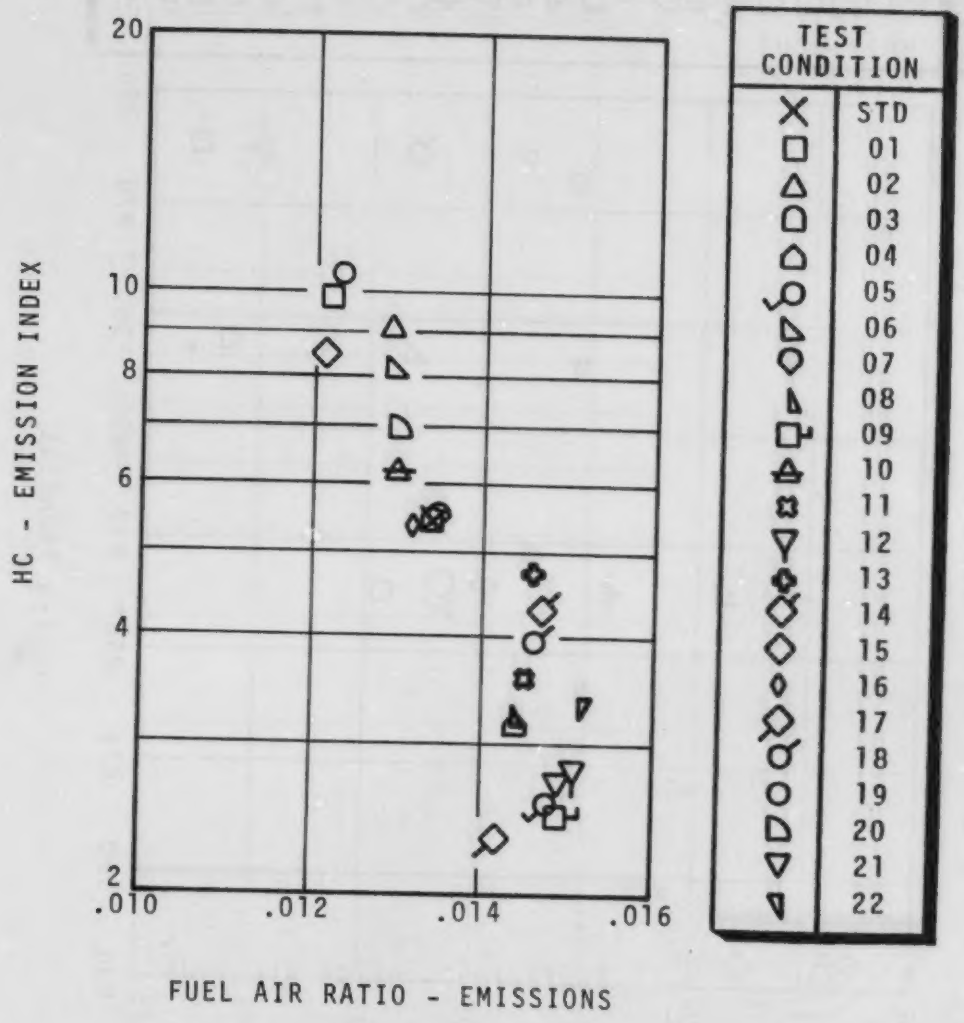


Figure 11-11. HC Emission Index Versus Fuel-Air Ratio, Rig Test - Idle.

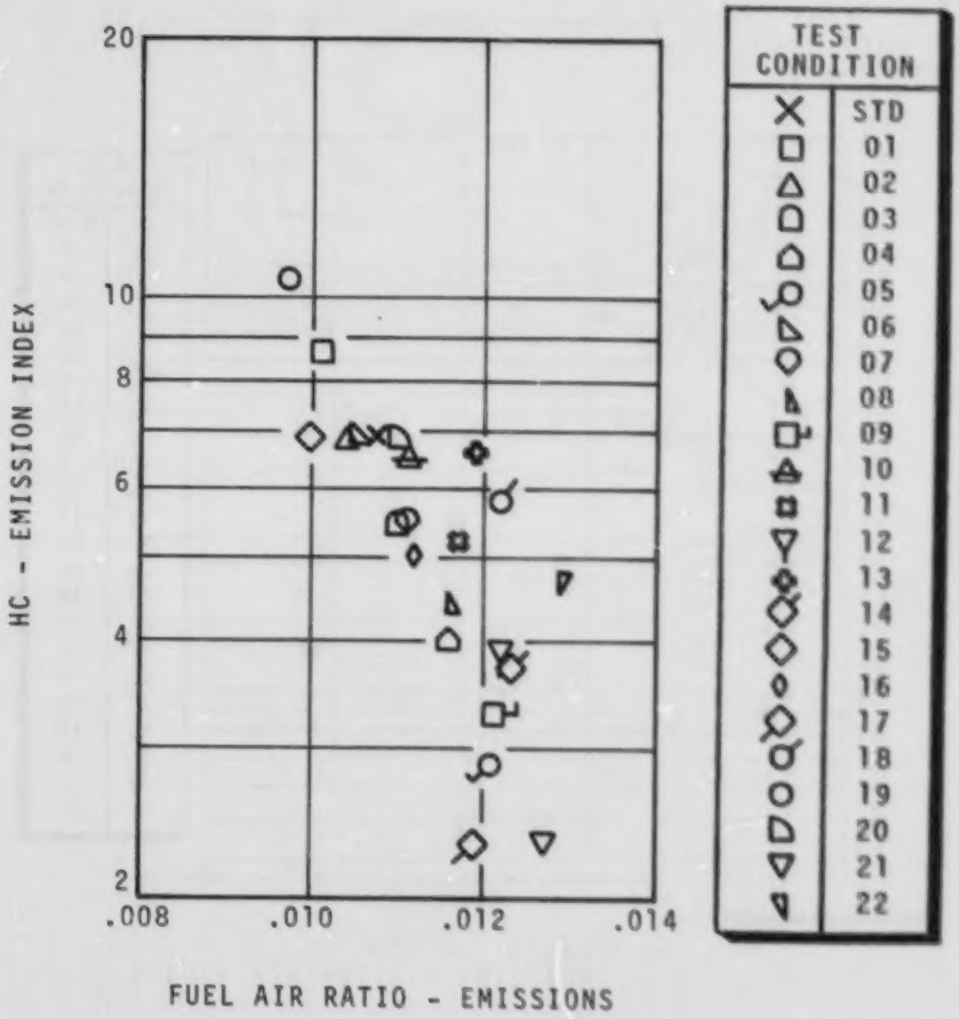


Figure 11-12. HC Emission Index Versus Fuel-Air Ratio, Rig Test - 1.5 x Idle.

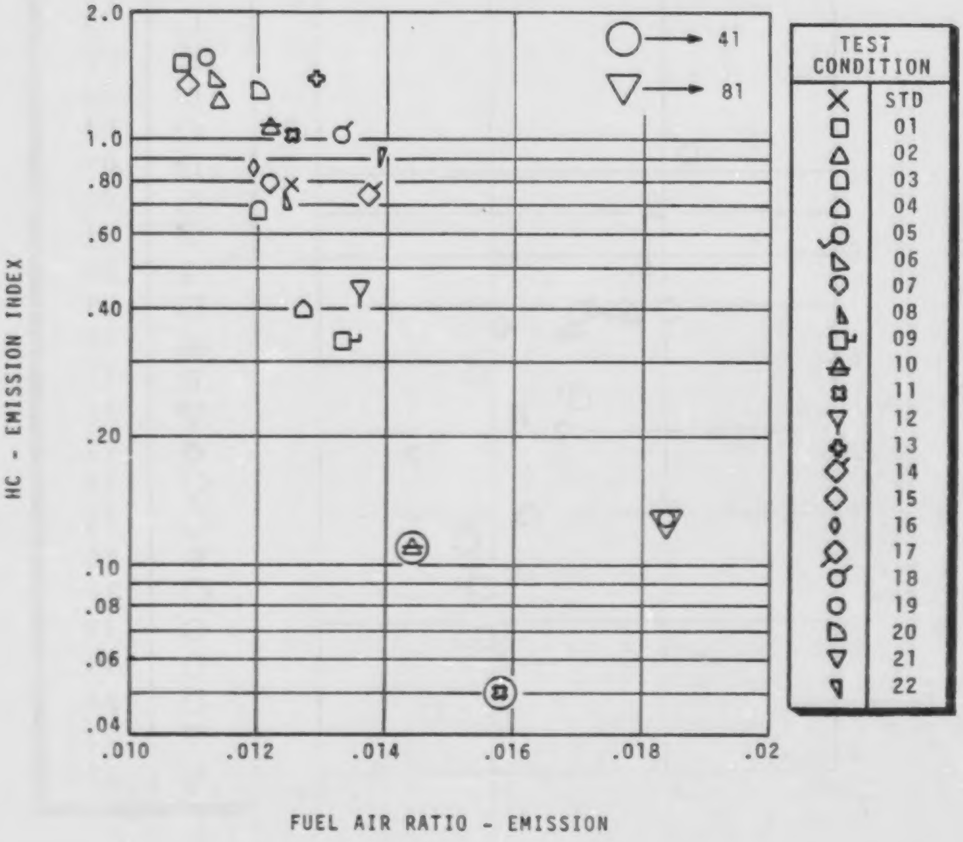


Figure 11-13. HC Emission Index Versus Fuel-Air Ratio, Rig Test - Approach.

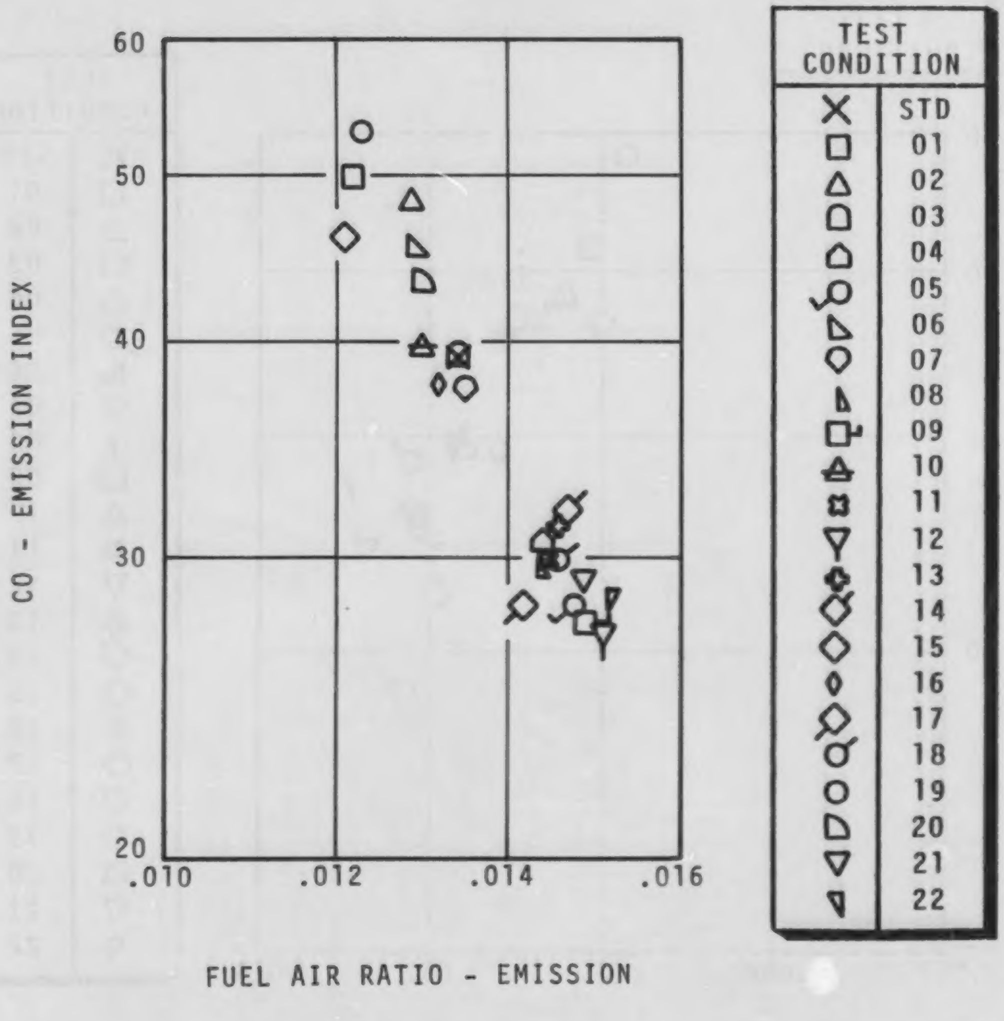


Figure 11-14. CO Emission Index Versus Fuel-Air Ratio, Rig Test - Idle.

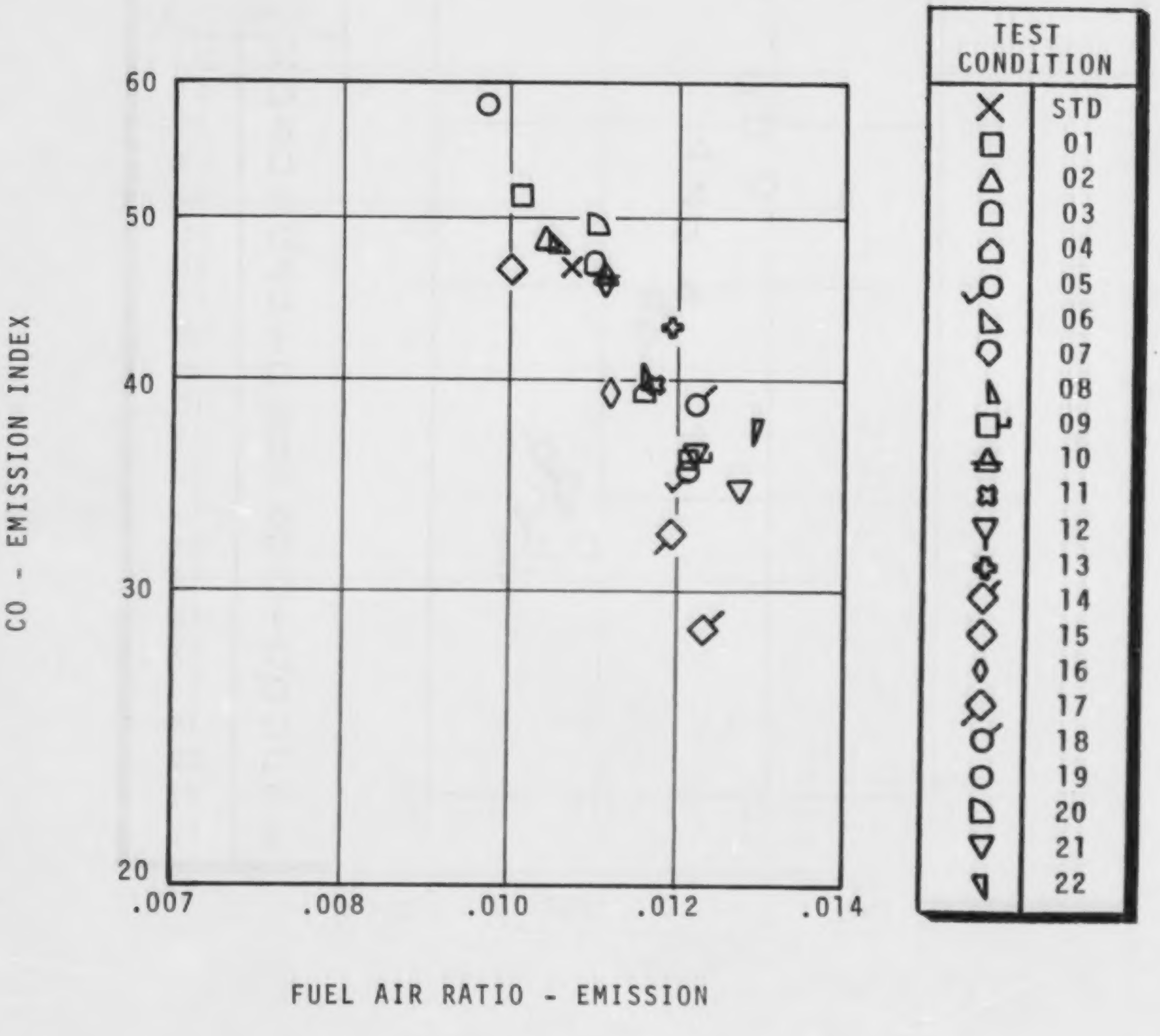


Figure 11-15. CO Emission Index Versus Fuel-Air Ratio, Rig Test - 1.5 x Idle.

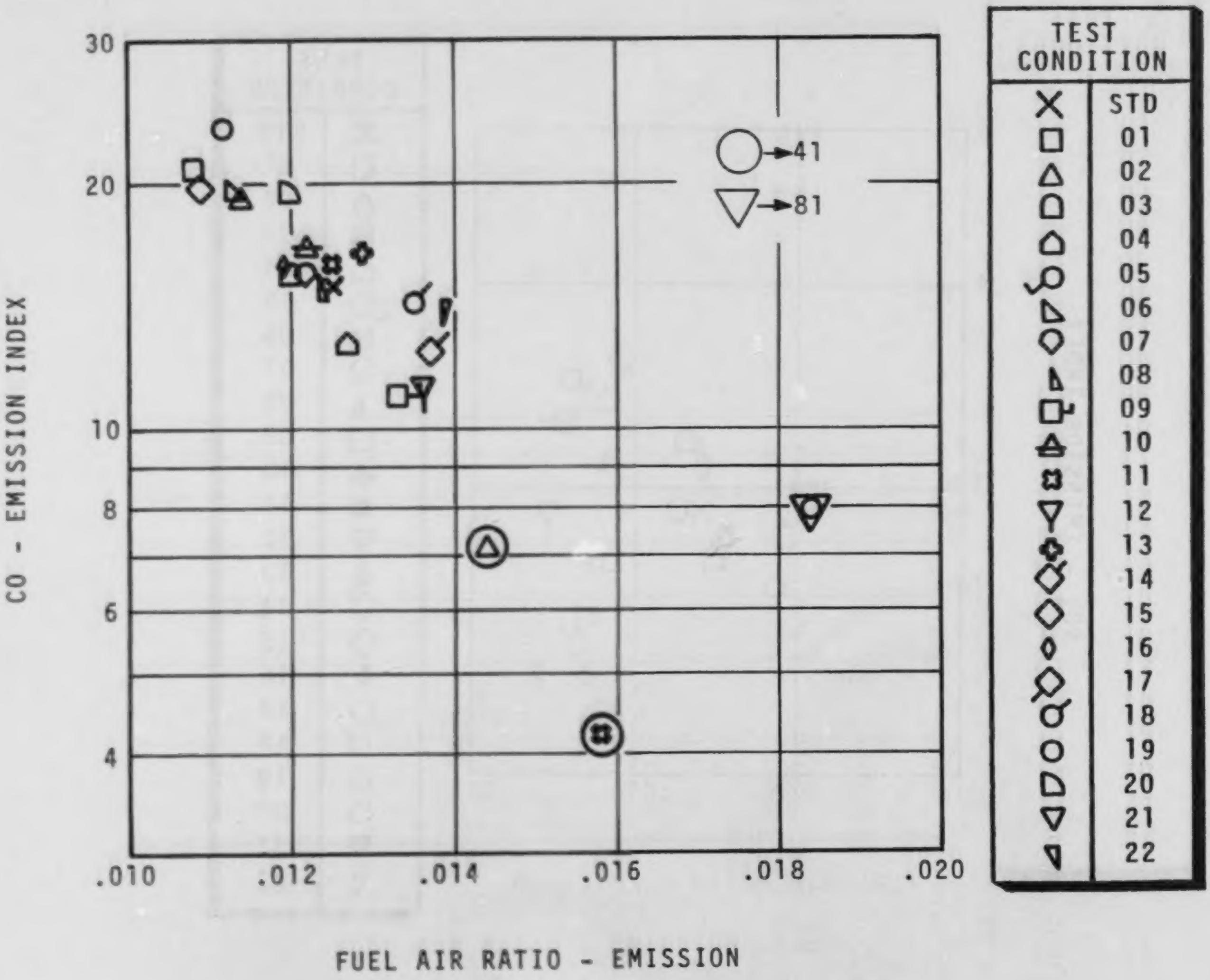


Figure 11-16. CO Emission Index Versus Fuel-Air Ratio, Rig Test - Approach.

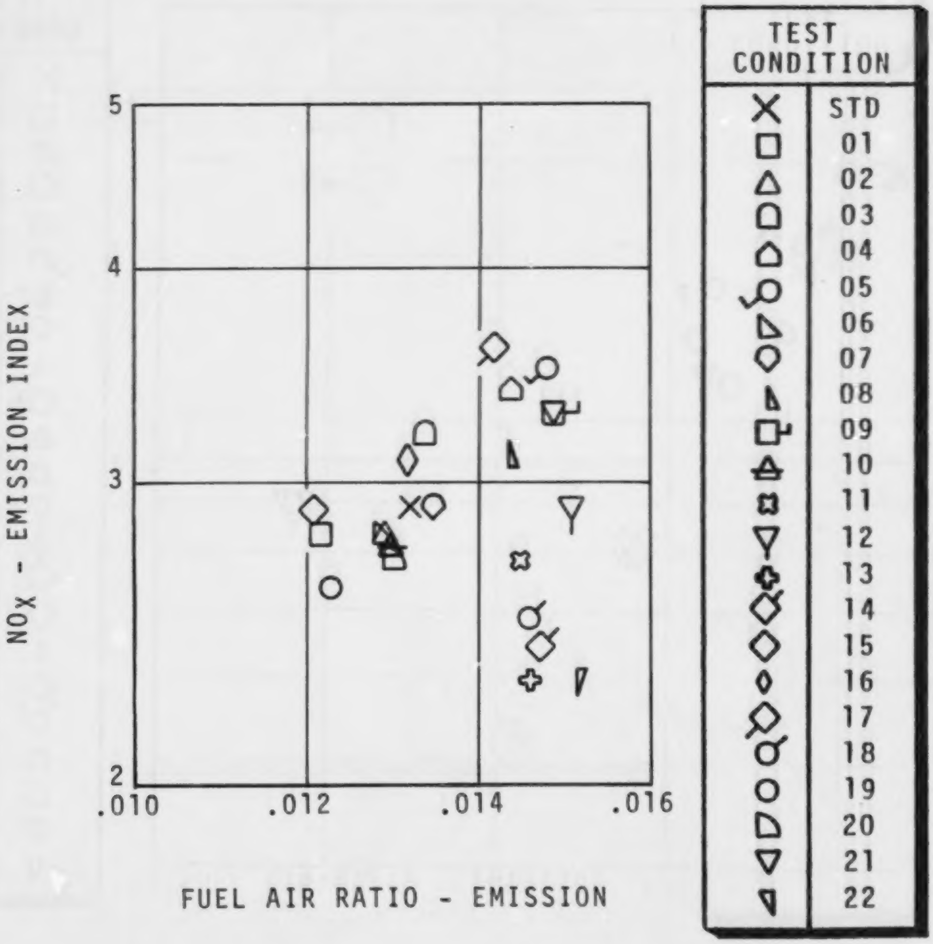


Figure 11-17. NO_x Emission Index Versus Fuel-Air Ratio, Rig Test - Idle.

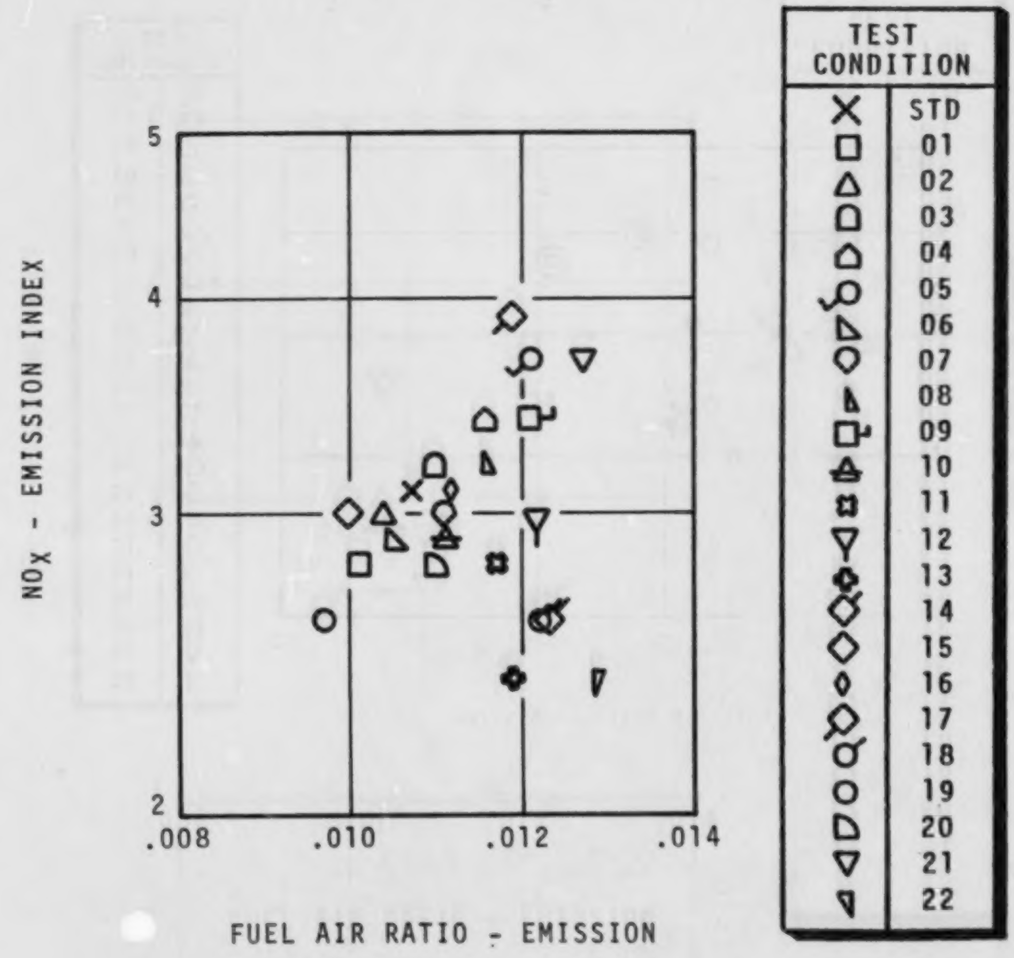


Figure 11-18. NO_x Emission Index Versus Fuel-Air Ratio, Rig Test - 1.5 x Idle.

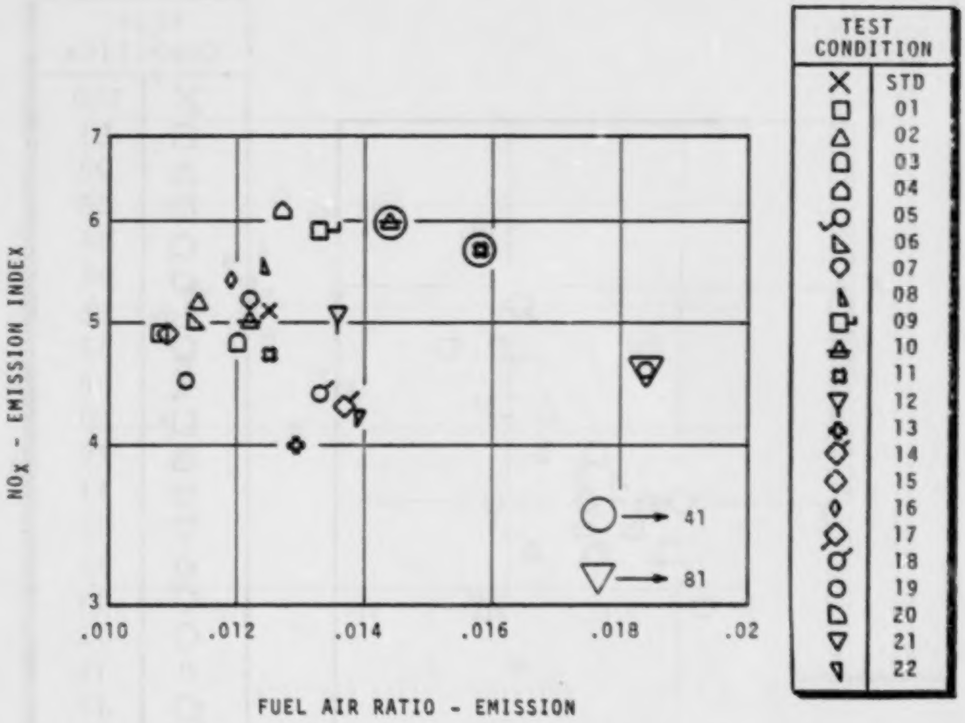


Figure 11-19. NO$_x$ Emission Index Versus Fuel-Air Ratio, Rig Test - Approach.

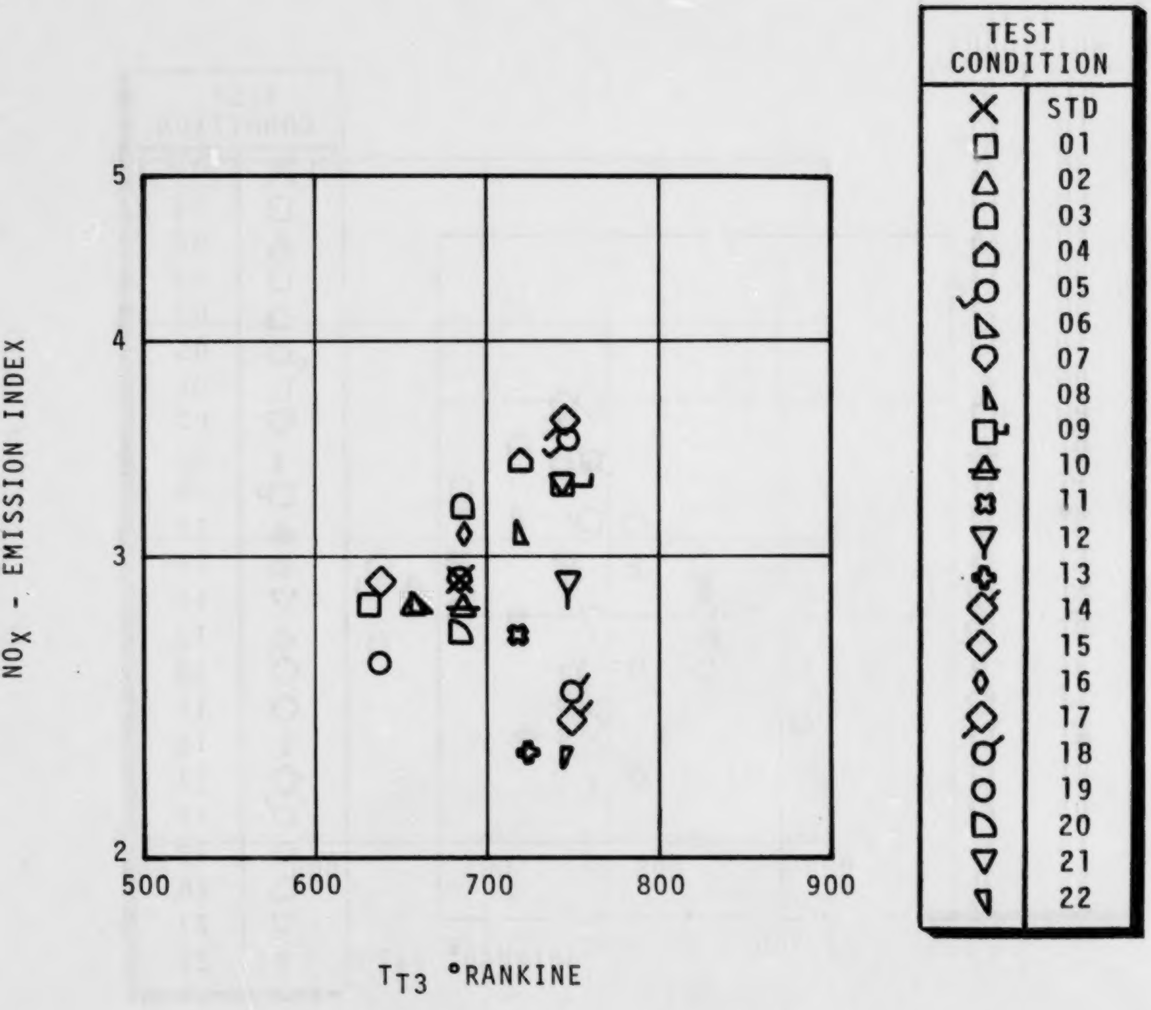


Figure 11-20. NO_x Emission Index Versus T_{t3}, Rig Test - Idle.

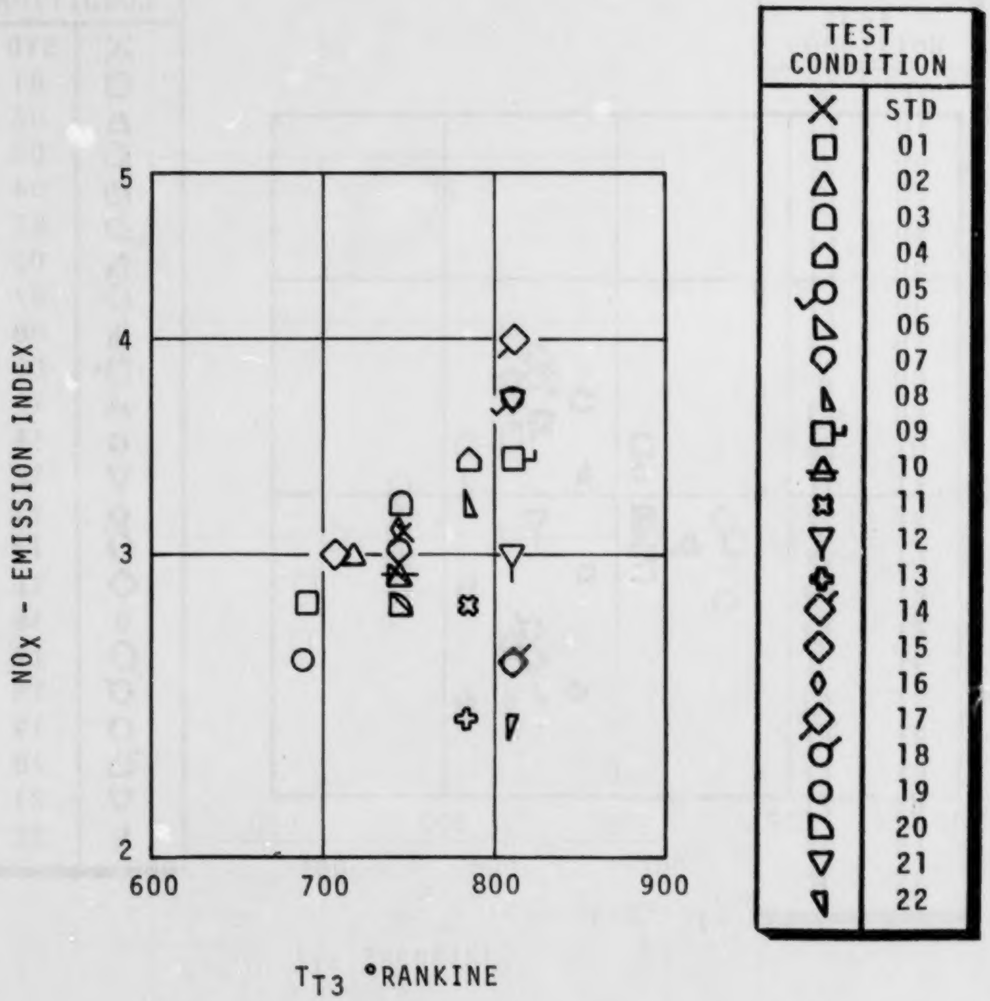


Figure 11-21. NO$_x$ Emission Index Versus T_{t3}, Rig Test - 1.5 x Idle.

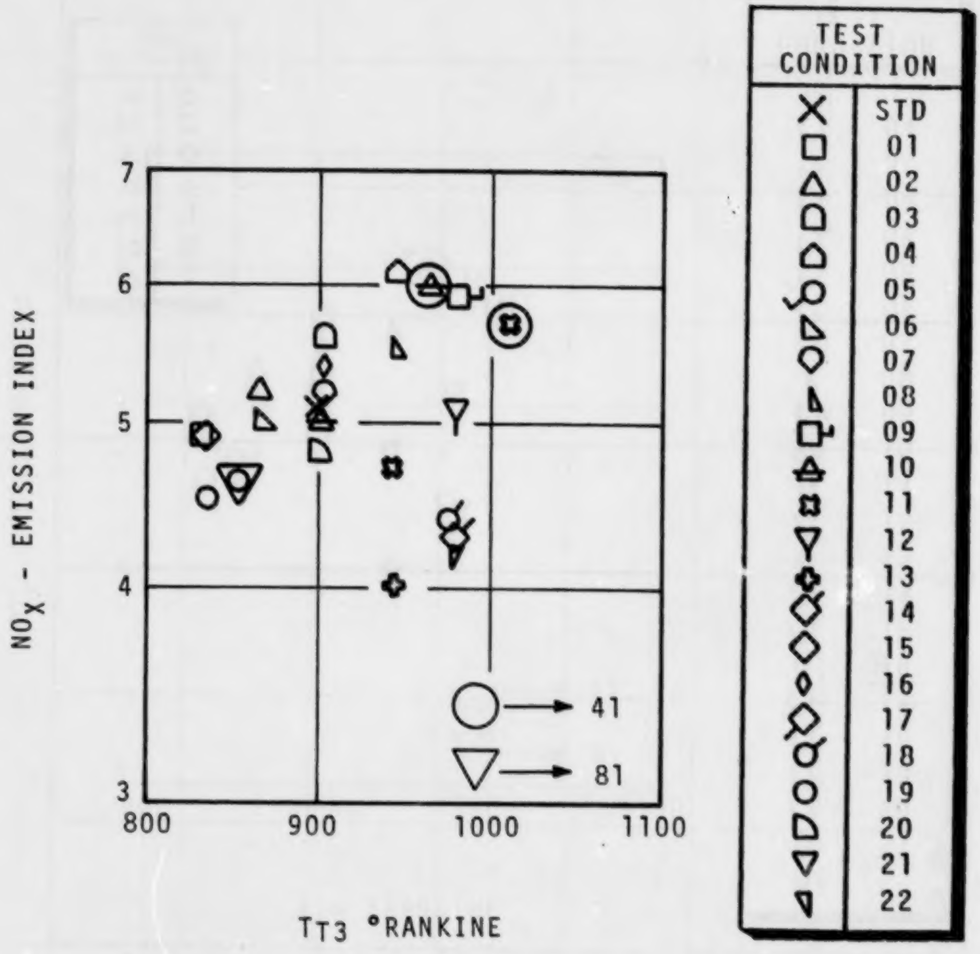


Figure 11-22. NO_x Emission Index Versus T_{t3}, Rig Test - Approach.

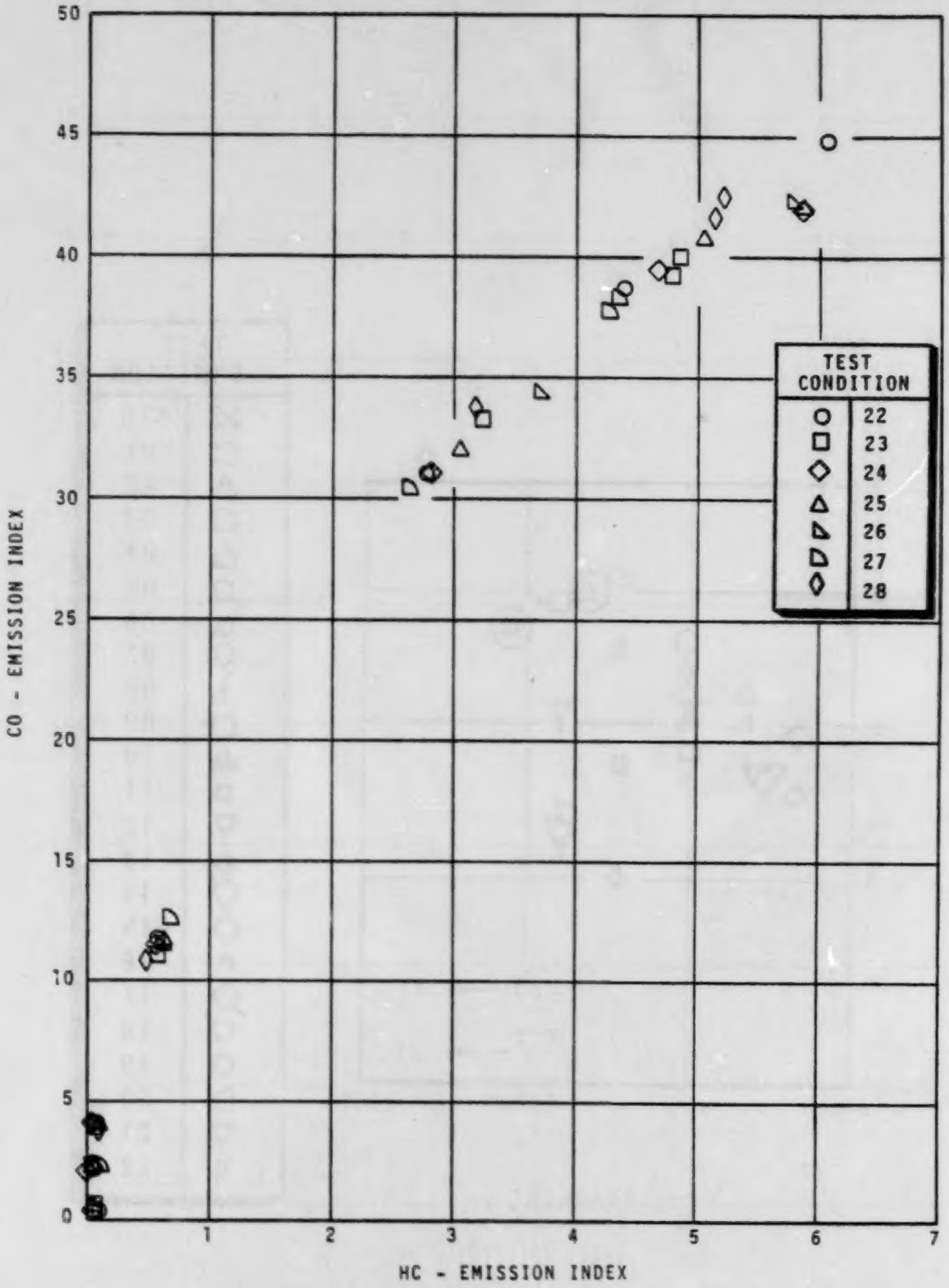


Figure 11-23. CO Emission Index Versus HC Emission Index, Engine Test.

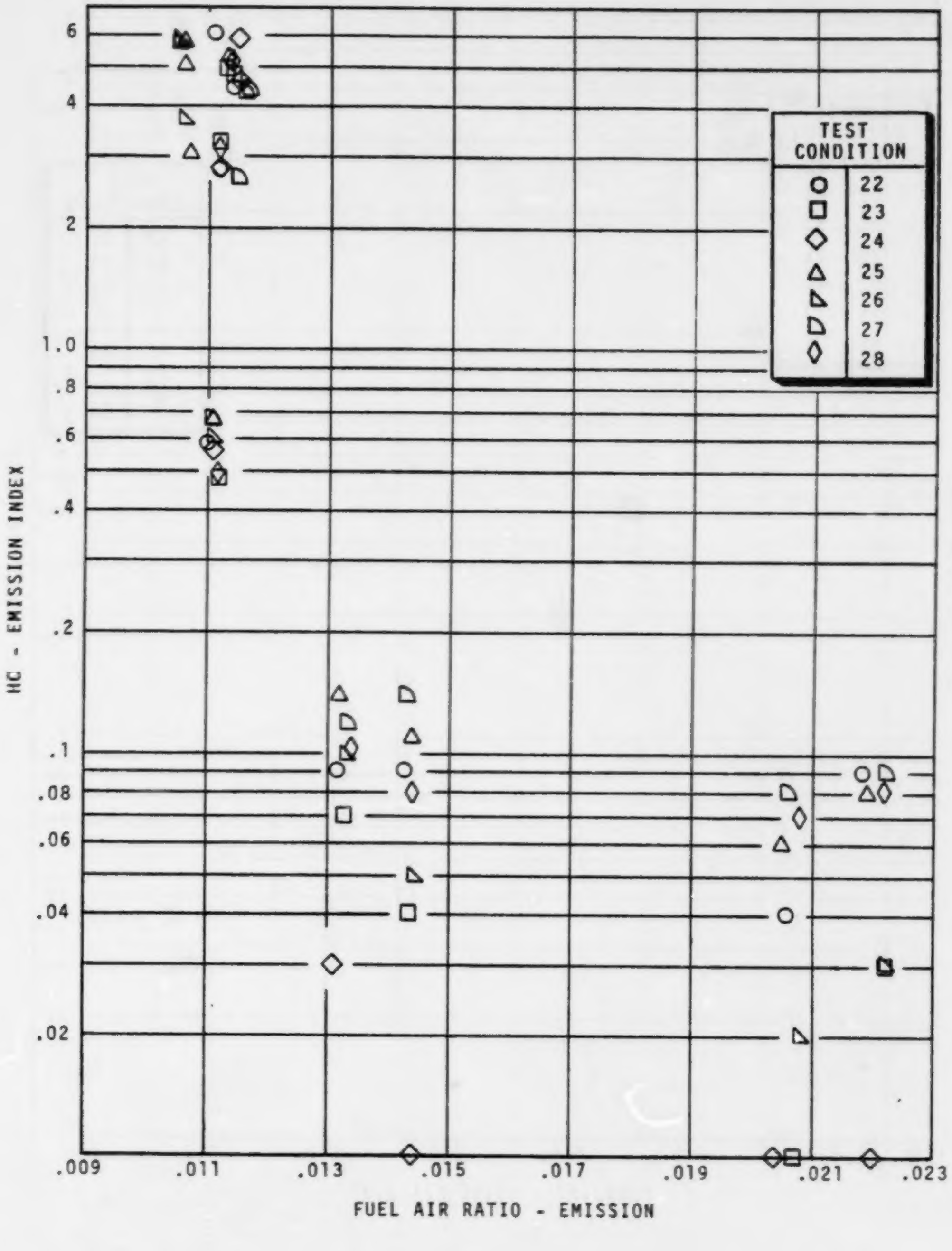


Figure 11-24. HC Emission Index Versus Fuel-Air Ratio, Engine Test.

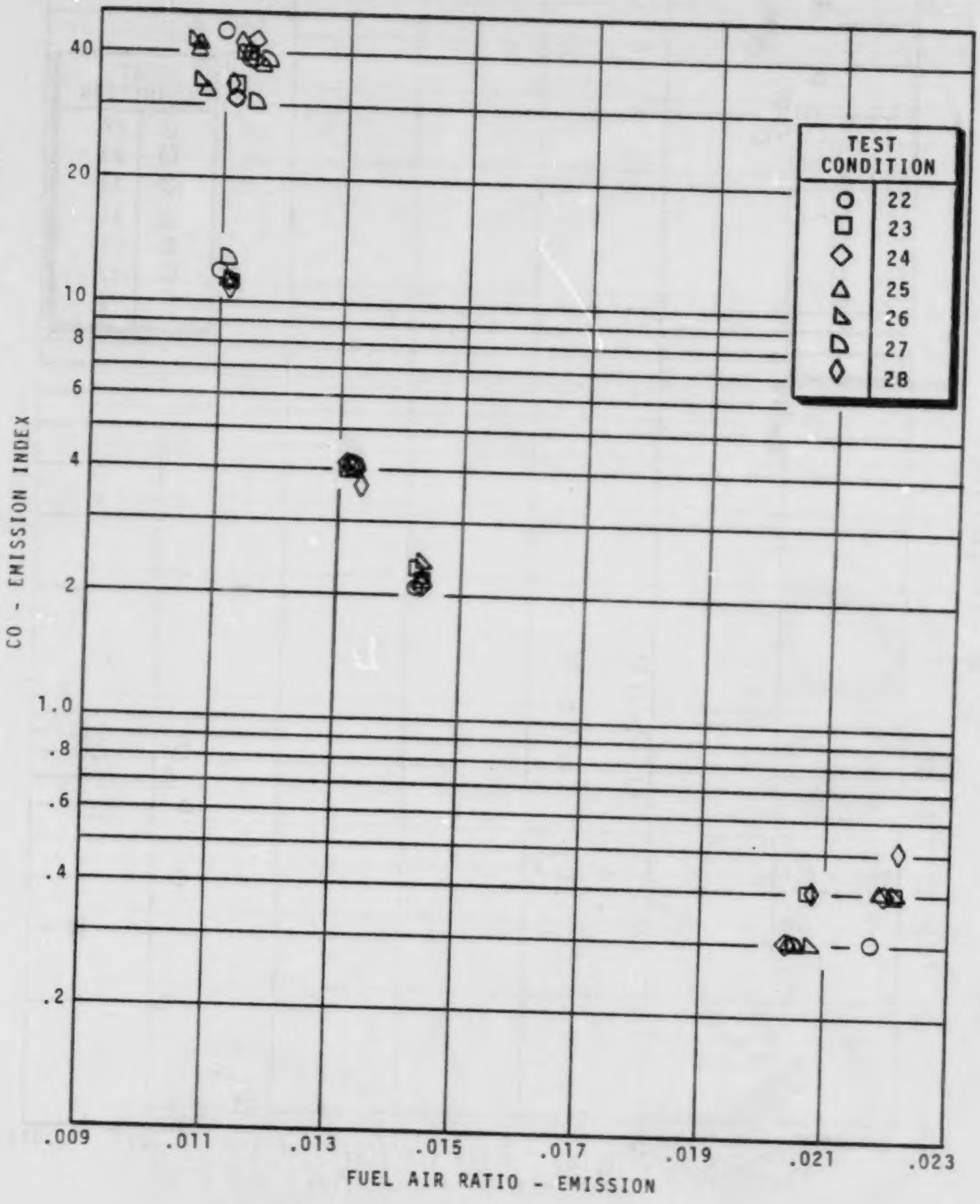


Figure 11-25. CO Emission Index Versus Fuel-Air Ratio, Engine Test.

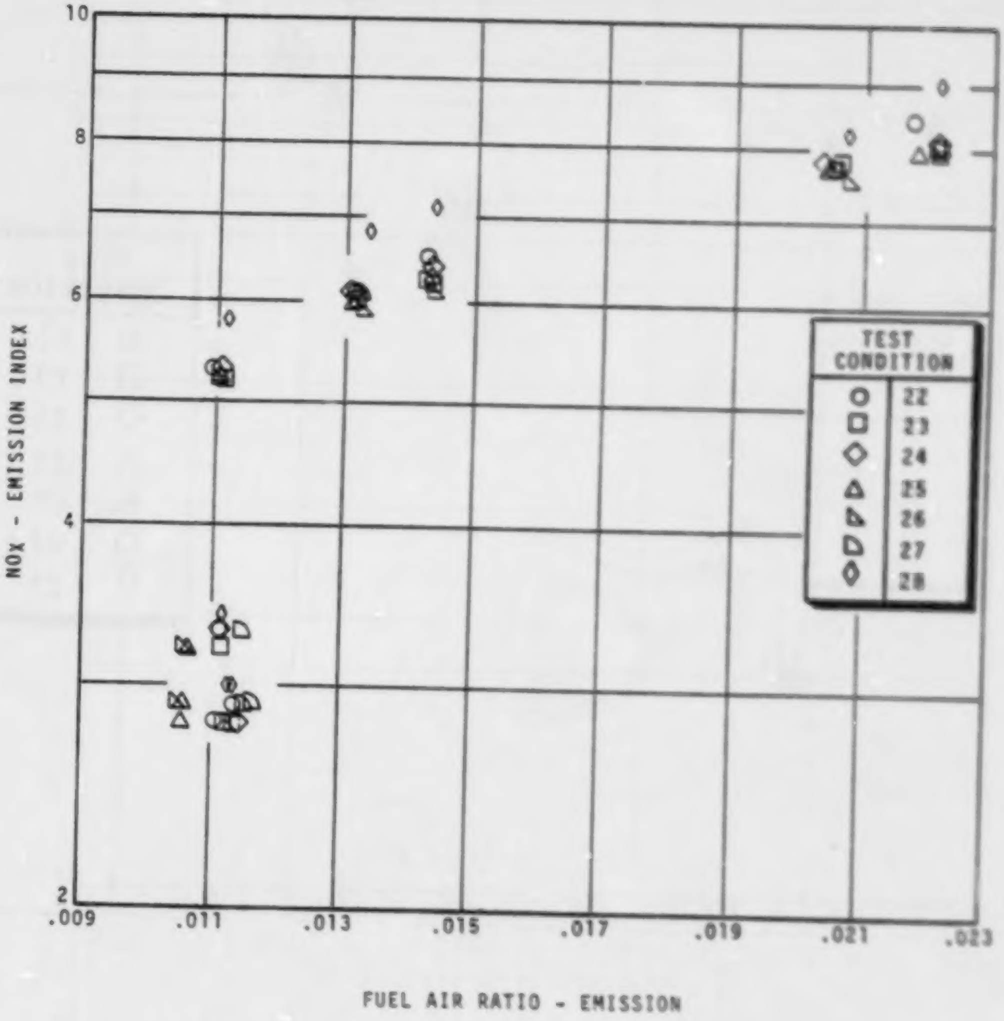


Figure 11-26. NO_x Emission Index Versus Fuel-Air Ratio, Engine Test.

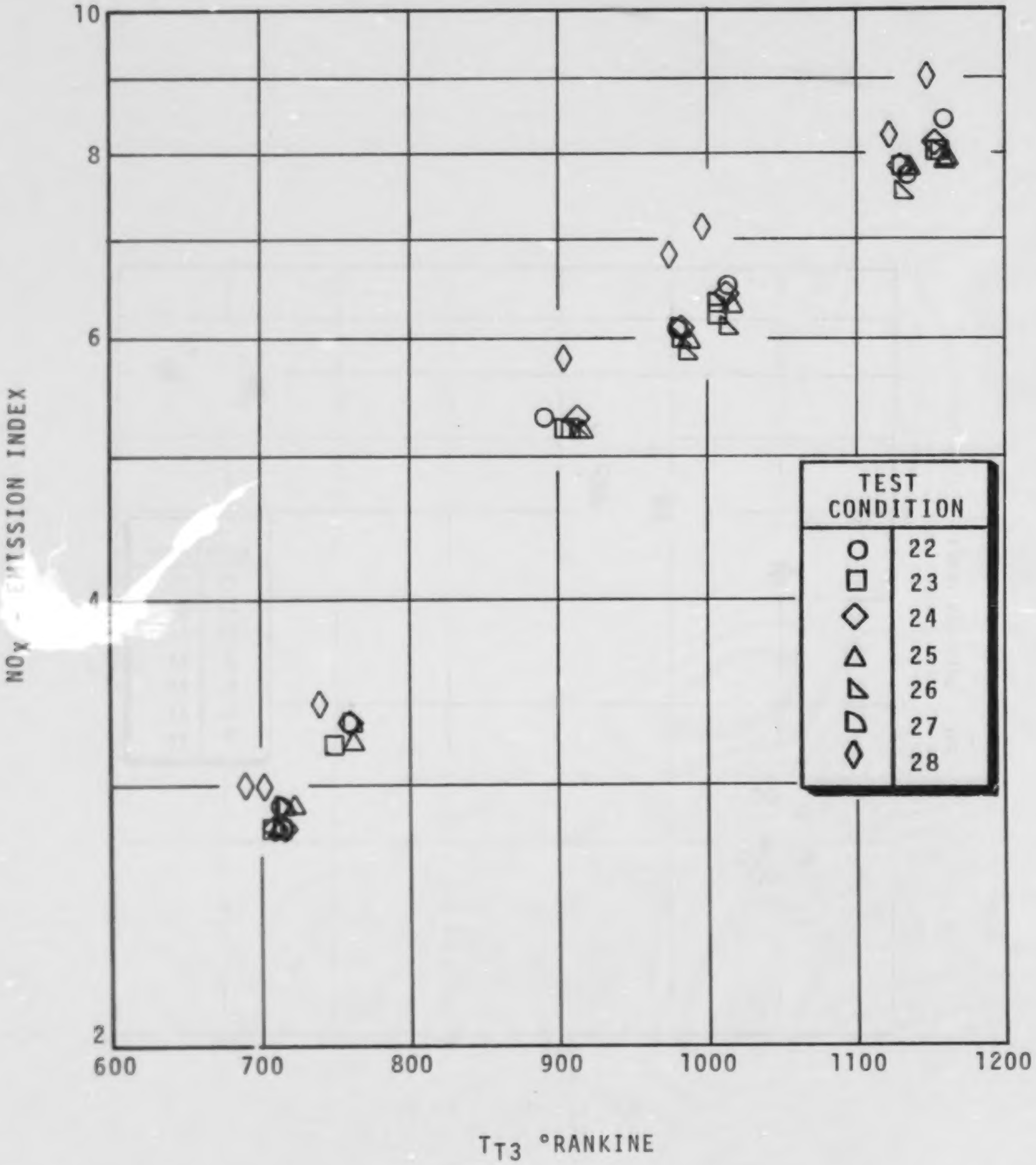


Figure 11-27. NO_x Emission Index Versus T_{t3}, Engine Test.

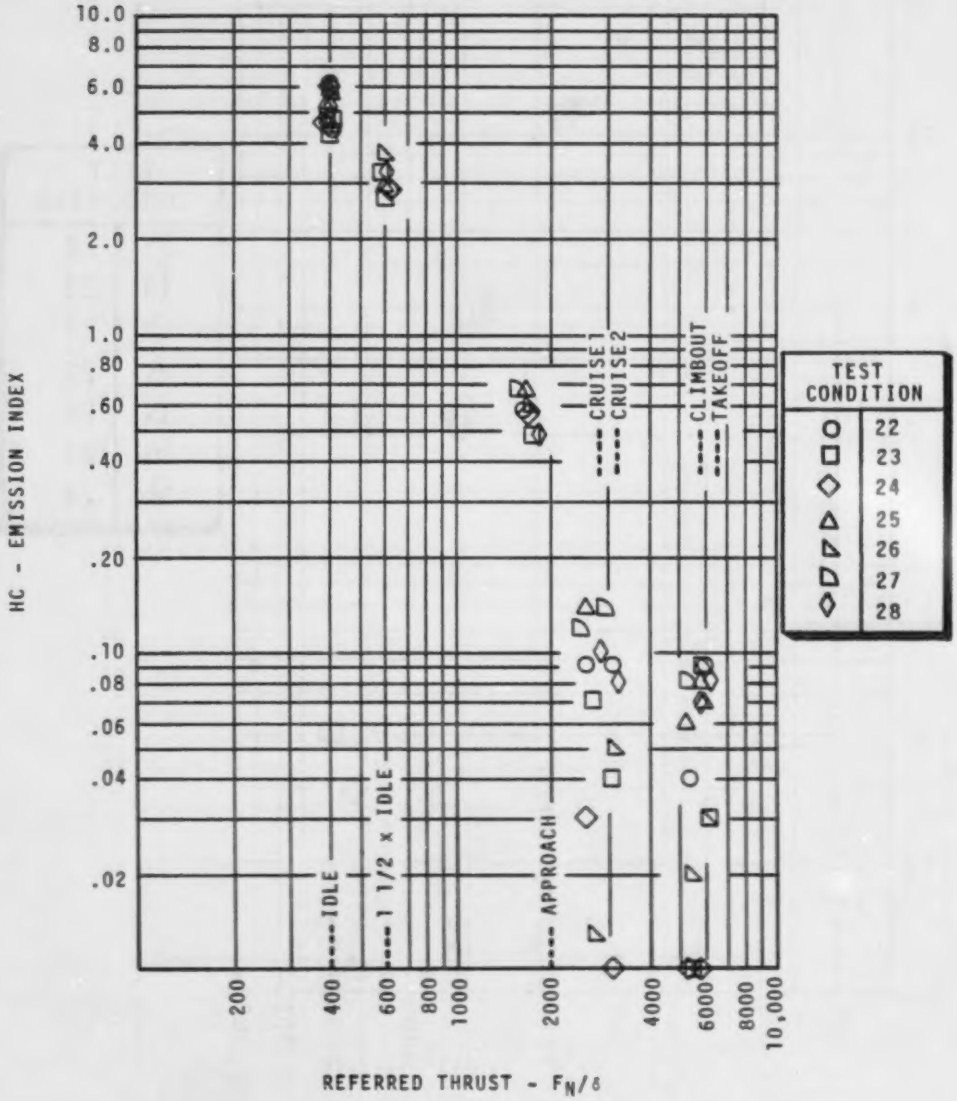


Figure 11-28. HC Emission Index Versus Referred Thrust, Engine Test.

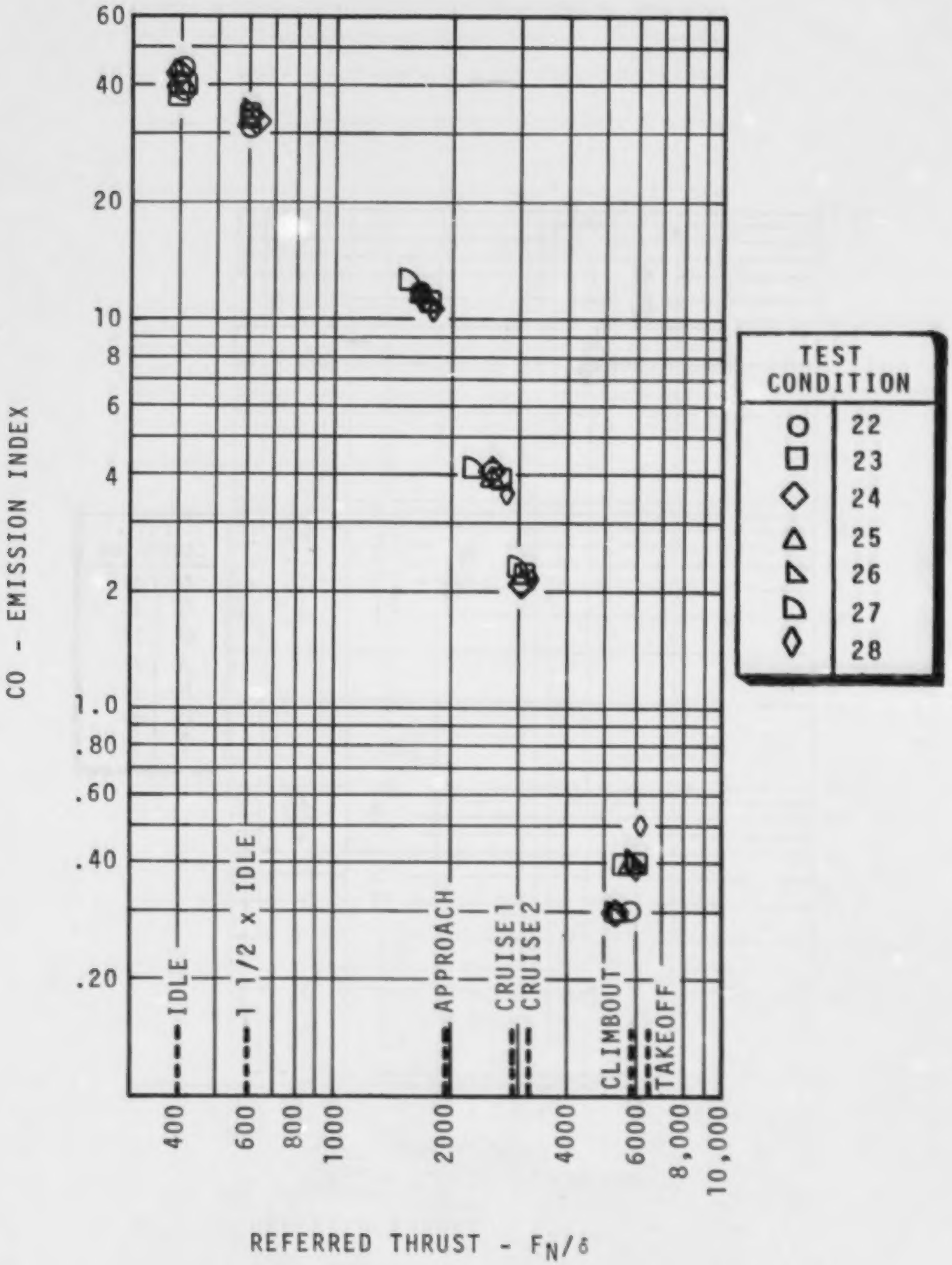


Figure 11-29. CO Emission Index Versus Referred Thrust, Engine Test.

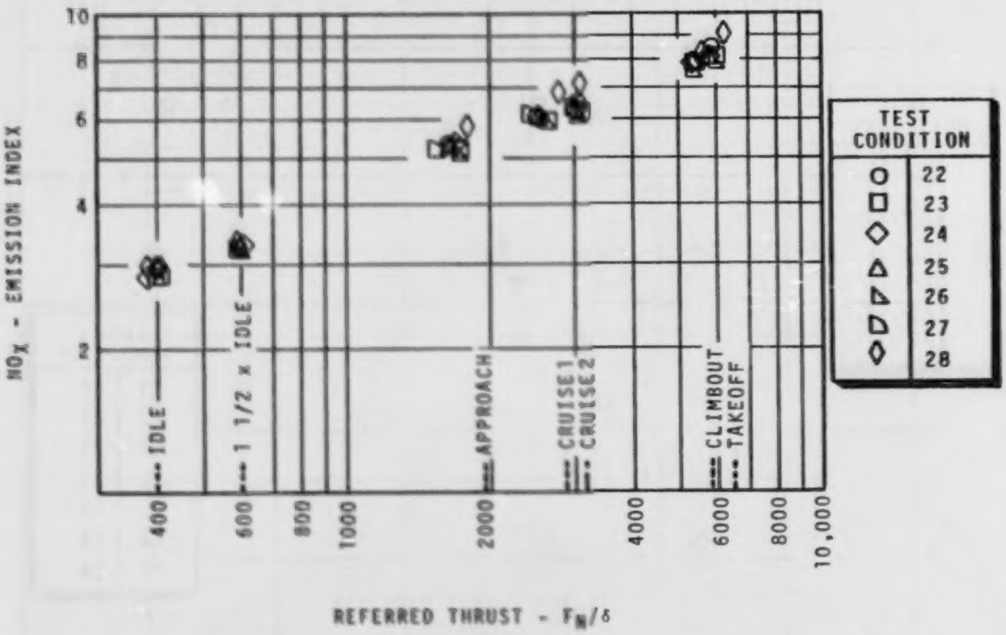


Figure 11-30. NO_x Emission Index Versus Referred Thrust, Engine Test.

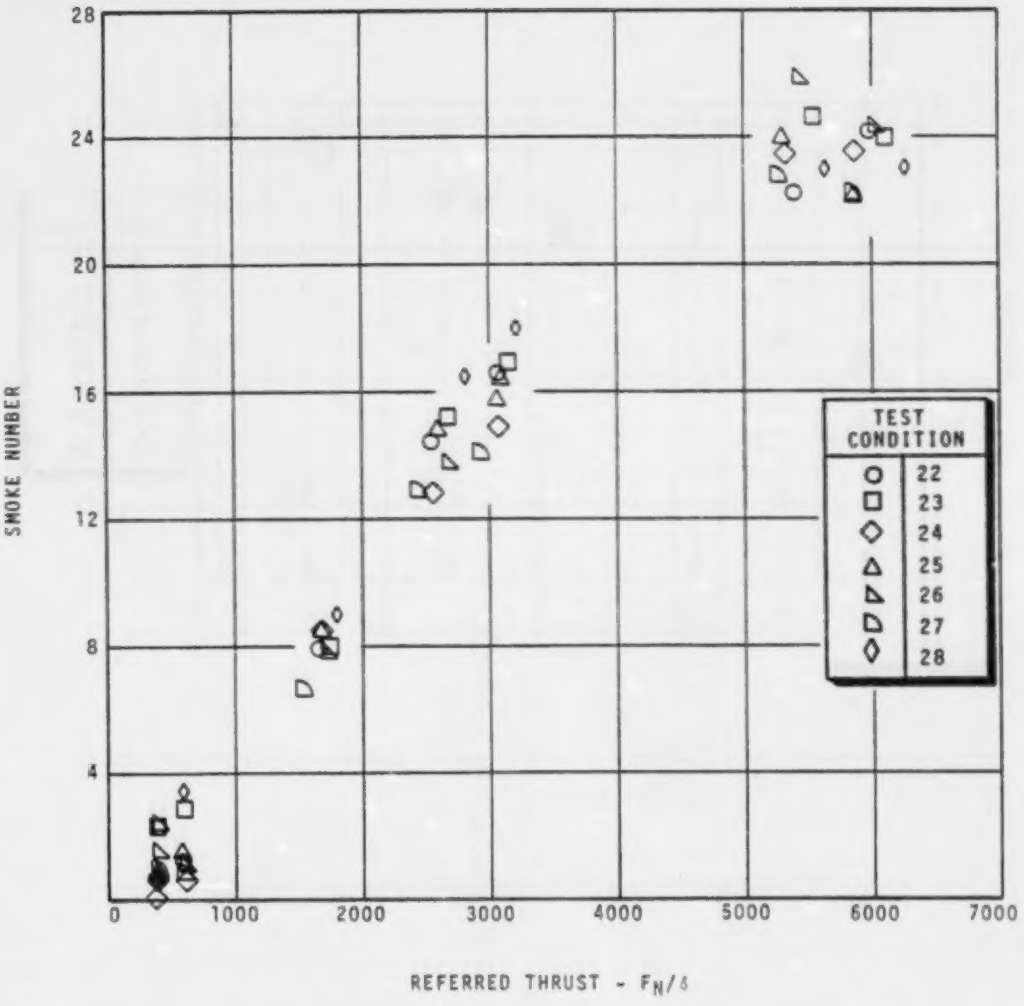


Figure 11-31. Smoke Number Versus Referred Thrust, Engine Test.

APPENDIX A
FEDERAL REGISTER CORRESPONDENCE

Appendix A includes the letter of 31 August 1976 from the EPA in response to Lycoming's letter or request for deviations from the procedures stated in Title 40, Part 87, of the Federal Register.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ANN ARBOR, MICHIGAN 48105
August 31, 1976

OFFICE OF
AIR AND WATER PROGRAMS

Mr. A.L. Ledewitz
Contract Administrator
AVCO, Lycoming Division
550 S. Main St.
Stratford, Conn. 06497

RECEIVED
SEP 2 - 1976
G. B. DAVIS

Dear Mr. Ledewitz:

Enclosed is a response to your letter requesting deviations from the prescribed test procedure as contracted to AVCO Lycoming in Contract Number 68-03-2383 "Determination of the Effects of Ambient Conditions on Aircraft Engine Emissions by Combustor Rig Testing". This enclosure presents a response to each variance requested with a statement of acceptance or rejection for that request.

Modification to content of the contract for incorporation of these revisions, is unnecessary since these modifications are within the stated authority of the Project Officer. These revisions provided shall therefore be incorporated into the performance of this contract.

Sincerely yours,

Gary Austin, Project Officer
Standards Development and Support Branch

cc: Albert Ahlquist

Determination of the Effects of Ambient Conditions
Contract Number 68-03-2383

This memo presents a response to AVCO Lycoming's request for variance to the Scope of Work of the subject contract. The contract requires that "Emission Measurements are to be conducted utilizing the instruments and measurement procedures specified in the Federal Register of July 17, 1973, pages 19088 through 19103. It is mandatory that this procedure be completely adhered to during every test, except where variance is granted by the project officer...".

Section 87.62(a)(1) Test Procedures (propulsion engines)

AVCO request - Delete the entire subsection

Response - This sub-section may be deleted in its entirety except for the first sentence of the second paragraph. This sentence modified slightly shall read as follows; Actual power setting, that when corrected to standard day conditions, corresponds to the contracted percent of power.

Section 87.64(d) Component description (exhaust gas analytical system)

AVCO request - Delete for combustor rig testing

Response - This section shall not be deleted because it is essential in the understanding of the sample and analytical system.

Section 87.64(c)(1)(ii)(d) (axial sampling plane)

AVCO request - None

Response - AVCO did not request that this section be deleted but in reference to their request that section 87.64(d) be deleted it is clear that they were referring to this section. This section shall be deleted.

Section 87.67(a) Sampling Procedures

AVCO request - Modify Sub-section (a)(1) through (4) as follows:

A "series of measurements" encompasses the testing made on a single test item (engine or combustor) in each separate installation. However, many of the listed checks will be made more often than once each series. The frequency of the checks to be run under this Paragraph, No. 87.67, will be as follows while testing.

(a) (1) Daily
(a) (2) Daily
(a) (3) Hourly
(a) (4) Hourly

Response - Rather than respond directly to the AVCO request the sub-section has been rewritten for this combustor rig test as follows.

Section 87.67(a)

(1) Check the sampling system for any leaks that could dilute the exhaust gas. Replace or clean sample line filters daily or more frequently if necessary to insure the integrity of the sample.

(2) Zero and Span Check.

(i) Introduce the zero grade gas at the same flow rate used to analyze the test samples and zero the analyzers. Obtain a stable reading on each amplifier meter and recorder. Record Readings.

(ii) Introduce span gases and set the CO and CO_2 analyzer gains, the HC analyzer sample capillary flow rate and electronic gain control, if provided, and the NOx analyzer high voltage supply or amplifier gain to match the calibration curves. In order to avoid corrections, span and calibrate at the same flow rates used to analyze the test samples. Span gases should have concentrations equal to approximately 80 percent of each range used. If the gain has shifted significantly on the CO or CO_2 analyzers, check tuning. If necessary, check the calibration. Show actual concentrations on chart. Log the gain readings. Record reading.

(3) If the zero or span of subparagraph (2) has shifted re-zero and then re-span analyzers. Record new readings. Upon completion of the re-span check zero.

(4) Zero and Span check of subparagraph (2) and (3) shall be performed at the end of the test but not less than once per hour.

Section 87.67(a) Sample Procedures

AVCO request - Sub-section (a)(5)

Change "2 seconds" to "approximately 10 seconds". Add "Residence time in sample line, between sample probe and emissions data acquisition system cabinet, must be under 2 seconds as computed by line length, diameter, and measured flow".

Response - This section is in the process of being modified through Technical Amendment to the aircraft emission regulations. The modified procedure shall be used in place of the present section. This procedure is:

(5) Check the sample system line temperature. Also check the emission measurement system response time using the following procedure:

(i) In addition to the requirements or paragraph 87.64, the sample system transport time shall be rechecked each time the emission measurement system is modified in any manner which may reasonably be expected to change the sample system transport time.

(ii) The emission measurement system response time shall be chacked. Introduce an HC span gas at the sample probe and measure the time it takes for the instrument to respond to 15% of span concentration. The emission measurement system response time shall be 7 seconds or less.

(iii) Repeat (ii) for the CO, CO_2, and NOx instrumentation. The emission measurement system response time for these instruments shall be 7 seconds or less except for the NOx, chemiluminescence, instrument which shall have a response time of 9 seconds or less.

(iv) The results of (ii) and (iii) must compare with the emission measurement system response times of the previous test within ± 1.0 second.

Section 87.67(a) Sample Procedures

AVCO request - Subsection (a)(6) & (10)

(6) Continuous Monitor
(10) Hourly

Response - Both of these requests follow the requirement of the federal regulations and the testing requirements of this program and are therefore acceptable.

Section 87.67(b)(2) Sample line contamination

AVCO request - Change: "Check sample line for contamination each time the instrument zero and span points are checked" is to read "Check sample line for excessive contamination before, and after, each series of measurements".

Response - The sentence of concern shall be modified to read as follows "Check sample line for contamination before, and after, each series of measurements". All other parts of the section shall remain the same.

APPENDIX B

COMBUSTOR DATA

```
COMBUSTOR RIG TEST                                                   001145
DATE                          DATA POINT       TEST CELL             001145
 1/18/77                      001145           1                     001145
INSTRUMENT OPERATOR                            TEST OPERATOR         001145
TREMBLEY                                       EHARDT                001145
ENGINE MANUFACTURER           MODEL            SERIAL NUMBER         001145
LYCOMING                      ALF-502          LF04                  001145
FUEL IDENT.                   FUEL FLOW PPH    MANIFOLD FUEL TEMP FAH 001145
JET-A HC RATIO 0.160           349.            224.7                 001145
ORIFICE AIRFLOW LB/SEC        PT3 PSIA         TT3 DEG.RANKINE       001145
  7.3                          35.2            684.2                 001145
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                   001145
 400.0                        0.0133                                 001145
SIMULATED INLET PRESSURE PO PSIA                                     001145
14.696                                                               001145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                           001145
518.7                                                                001145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                  001145
 42.3                                                                001145
FILTER AREA .385 SI                                                  001145
CLEAN CK SMOKE NUMBER 0                                              001145
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH  001145
         2.3               3.0         0.48     11.270            75.0  001145
         2.3               4.0         0.48     11.270            75.0  001145
         2.3               7.0         0.48     11.270            75.0  001145
         4.5              11.0         0.48     11.270            75.0  001145
GASEOUS EMISSIONS                                                    001145
                   FID       NDIR      NDIR      CHEMI     CHEMI     001145
                   UHC        CO        CO2       NO        NOX      001145
RANGE               2         2         2         1         1        001145
INSTR GAS TEMP     153.      62.       62.       64.       64.       001145
RAW VALUE MV       15.4    1005.2     590.6     550.6    1007.1      001145
GAS CONCEN PPM(C)  150.4     538.8   26860.5      13.4      24.5     001145
GAS CONCEN PCT     0.0150    0.0539    2.6860    0.0013    0.0024    001145
EMISSION INDEX     5.46      39.3      3080.        1.6       2.9    001145
FUEL-AIR RATIO     0.0134                                            001145
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COMBUSTOR RIG TEST
DATE                             DATA POINT             TEST CELL                     002145
 1/20/77                         002145                 1                             002145
INSTRUMENT OPERATOR                                                                   002145
TREMBLEY                                                TEST OPERATOR                 002145
ENGINE MANUFACTURER                                     EHARDT                        002145
LYCOMING                         MODEL                  SERIAL NUMBER                 002145
FUEL IDENT.                      ALF-502                LF04                          002145
JET-A HC RATIO 0.160             FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH        002145
ORIFICE AIRFLOW LB/SEC            416.                  225.9                         002145
 10.7                            PT3 PSIA               TT3 DEG.RANKINE               002145
SIMULATED THRUST LBS              40.2                  745.9                         002145
 600.0                           FUEL-AIR RATIO MEAS.                                 002145
SIMULATED INLET PRESSURE PO PSIA 0.0108                                               002145
14.696                                                                                002145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                            002145
518.7                                                                                 002145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                   002145
 44.0                                                                                 002145
FILTER AREA .385 SI                                                                   002145
CLEAN CK SMOKE NUMBER 0                                                               002145
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH             002145
         2.3                 3.0          0.50      11.270                            002145
         2.3                 4.0          0.50      11.270              76.0          002145
         2.3                 7.0          0.50      11.320              76.0          002145
         6.5                11.0          0.50      11.320              77.0          002145
GASEOUS EMISSIONS                                                       77.0          002145
                      FID        NDIR        NDIR        CHEMI       CHEMI            002145
                      UHC        CO          CO2         NO          NOX              002145
RANGE                  2          3           2           1           1               002145
INSTR GAS TEMP        153.       56.         56.         64.         64.              002145
RAW VALUE MV           15.6      408.1       483.7       450.6       506.4            002145
GAS CONCEN PPM(C)      152.1      508.0       21259.7       10.3        20.8          002145
GAS CONCEN PCT        0.0152     0.0508      2.1260      0.0010      0.0021           002145
EMISSION INDEX         6.54       46.6       3063.          1.9         3.1           002145
FUEL-AIR RATIO        0.0107                                                          002145
                                                                                      002145
```

```
COMBUSTOR RIG TEST
DATE
 1/20/77                    DATA POINT          TEST CELL                    003144
INSTRUMENT OPERATOR.        003144              1                            003144
TREMBLEY                                        TEST OPERATOR                003144
ENGINE MANUFACTURER                             FFARET                       003144
LYCOMING                    MODEL               SERIAL NUMBER                003144
FUEL IDENT.                 ALF-502             LF04                         003144
JET-A HC RATIO 0.160        FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH       003144
ORIFICE AIRFLOW LB/SEC       804.               227.4                        003144
 17.5                       PT3 PSIA            TT3 DEG.RANKINE              003144
SIMULATED THRUST LBS         75.2               898.5                        003144
1950.0                      FUEL-AIR RATIO MEAS.                             003144
SIMULATED INLET PRESSURE P0 PSIA 0.0127                                      003144
14.696                                                                       003144
SIMULATED INLET TEMPERATURE T0 DEG.RANKINE                                   003144
518.7                                                                        003144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                          003144
 44.9                                                                        003144
FILTER AREA .385 SI                                                          003144
CLEAN CK SMOKE NUMBER 0                                                      003144
SMOKE NUMBER         VOL.-LITERS                                             003144
      10.9                    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH            003144
       6.7              3.0        0.60     11.170                           003144
      10.9              4.0        0.52     11.370           77.0            003144
      14.9              7.0        0.52     11.370           77.0            003144
GASEOUS EMISSIONS      11.0        0.53     11.370           77.0            003144
                                                             78.0            003144
                  FID        NDIR        NDIR       CHEMI                    003144
RANGE             UHC        CO          CO2        NO         CHEMI         003144
INSTR GAS TEMP     1          2           2         NO         NOX           003144
RAW VALUE MV      153.       59.         59.         2          2            003144
GAS CONCEN PPM(C)  25.7      437.9       560.6      64.        64.           003144
GAS CONCEN PCT      19.9      191.2     25438.3     338.1      434.8         003144
EMISSION INDEX    0.0020     0.0191      2.5438       31.0       40.0        003144
FUEL-AIR RATIO     0.78      15.0        3133.      0.0031     0.0040        003144
                  0.0125                              4.0        5.1         003144
                                                                             003144
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COMBUSTOR RIG TEST                                                          191135
DATE                       DATA POINT         TEST CELL                     191135
 2/ 1/77                   191135             1                             191135
INSTRUMENT OPERATOR                           TEST OPERATOR                 191135
TREMBLEY                                      EHARDT                        191135
ENGINE MANUFACTURER        MODEL              SERIAL NUMBER                 191135
LYCOMING                   ALF-502            LF04                          191135
FUEL IDENT.                FUEL FLOW PPH      MANIFOLD FUEL TEMP FAH        191135
JET-A HC RATIO 0.158        285.              226.5                         191135
ORIFICE AIRFLOW LB/SEC     PT3 PSIA           TT3 DEG.RANKINE               191135
  6.5                       30.6              637.0                         191135
SIMULATED THRUST LBS       FUEL-AIR RATIO MEAS.                             191135
 400.0                     0.0122                                           191135
SIMULATED INLET PRESSURE PO PSIA                                            191135
12.761                                                                      191135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                  191135
478.7                                                                       191135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         191135
 24.9                                                                       191135
FILTER AREA .385 SI                                                         191135
CLEAN CK SMOKE NUMBER 0                                                     191135
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   191135
         2.3                  3.0          0.50     11.358           76.0   191135
         0.0                  4.0          0.50     11.382           76.0   191135
         0.0                  7.0          0.50     11.333           75.0   191135
         6.7                 11.0          0.50     11.333           75.0   191135
GASEOUS EMISSIONS                                                           191135
                    FID        NDIR       NDIR       CHEMI      CHEMI       191135
                    UHC         CO         CO2        NO         NOX        191135
RANGE                2          3          2          1          1          191135
INSTR GAS TEMP      153.       59.        59.        64.        64.         191135
RAW VALUE MV         22.6      486.3      551.3      399.5      807.1       191135
GAS CONCEN PPM(C)    265.0      667.2      24403.5        9.6       19.5    191135
GAS CONCEN PCT      0.0265     0.0667     2.4404     0.0010     0.0020      191135
EMISSION INDEX      10.46       53.0      3048.         1.3        2.6      191135
FUEL-AIR RATIO      0.0123                                                  191135
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COMBUSTOR RIG TEST                                                             011135
DATE                         DATA POINT            TEST CELL                   011135
 3/ 3/77                     011135                1                           011135
INSTRUMENT OPERATOR                                TEST OPERATOR               011135
TREMBLEY                                           EHARDT                      011135
ENGINE MANUFACTURER          MODEL                 SERIAL NUMBER               011135
LYCOMING                     ALF-502               LF04                        011135
FUEL IDENT.                  FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH      011135
JET-A HC RATIO 0.158          330.                 226.7                       011135
ORIFICE AIRFLOW LB/SEC       PT3 PSIA              TT3 DEG.RANKINE             011135
  7.5                         35.1                 632.5                       011135
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                              011135
 400.0                       0.0122                                            011135
SIMULATED INLET PRESSURE PO PSIA                                               011135
14.696                                                                         011135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                     011135
478.7                                                                          011135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                            011135
 24.7                                                                          011135
FILTER AREA .385 SI                                                            011135
CLEAN CK SMOKE NUMBER 0                                                        011135
SMOKE NUMBER       VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH        011135
        0.0                3.0         0.50      11.422             77.0       011135
        4.5                4.0         0.50      11.422             77.0       011135
        6.7                7.0         0.50      11.422             77.0       011135
        6.7               11.0         0.50      11.471             77.0       011135
GASEOUS EMISSIONS                                                              011135
                   FID          NDIR         NDIR         CHEMI      CHEMI     011135
                   UHC           CO          CO2           NO         NOX      011135
RANGE               2            3            2             1          1       011135
INSTR GAS TEMP     154.         66.          66.           64.        65.      011135
RAW VALUE MV        28.2        467.2        549.3         388.7      664.8    011135
GAS CONCEN PPM(C)   246.3        618.8       24226.3          9.2       21.0   011135
GAS CONCEN PCT     0.0246       0.0619       2.4226        0.0009     0.0021   011135
EMISSION INDEX      9.81         49.7        3055.            1.2        2.8   011135
FUEL-AIR RATIO     0.0122                                                      011135
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                                                                              151135
COMBUSTOR RIG TEST                                                            151135
DATE                       DATA POINT          TEST CELL                      151135
 3/ 3/77                   151135              1                              151135
INSTRUMENT OPERATOR                            TEST OPERATOR                  151135
TREMBLEY                                       EHARCT                         151135
ENGINE MANUFACTURER        MODEL               SERIAL NUMBER                  151135
LYCOMING                   ALF-502             LF04                           151135
FUEL IDENT.                FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH         151135
JET-A HC RATIO 0.158        355.               226.8                          151135
ORIFICE AIRFLOW LB/SEC     PT3 PSIA            TT3 DEG.RANKINE                151135
  8.1                       37.9               638.5                          151135
SIMULATED THRUST LBS       FUEL-AIR RATIO MEAS.                               151135
 400.0                     0.0121                                             151135
SIMULATED INLET PRESSURE P0 PSIA                                              151135
15.855                                                                        151135
SIMULATED INLET TEMPERATURE T0 DEG.RANKINE                                    151135
478.7                                                                         151135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           151135
 24.9                                                                         151135
FILTER AREA .385 SI                                                           151135
CLEAN CK SMOKE NUMBER 0                                                       151135
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       151135
        0.0                 3.0          0.50     11.423             76.0     151135
        2.3                 4.0          0.50     11.472             76.0     151135
        4.5                 7.0          0.50     11.472             76.0     151135
       12.9                11.0          0.50     11.472             76.0     151135
GASEOUS EMISSIONS                                                             151135
                   FID         NDIR        NDIR        CHEMI       CHEMI      151135
                   UHC          CO          CO2         NO          NOX       151135
RANGE               2           3           2           1           1         151135
INSTR GAS TEMP     154.        53.         53.         64.         64.        151135
RAW VALUE MV        24.2      442.5       548.6       402.0       531.4       151135
GAS CONCEN PPM(C)   211.3      571.0      24195.1        5.5         22.2     151135
GAS CONCEN PCT     0.0211      0.0571      2.4195      0.0010      0.0022     151135
EMISSION INDEX      8.46       46.0       3065.          1.3          2.9     151135
FUEL-AIR RATIO     0.0121
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COMBUSTOR RIG TEST                                                      021135
DATE                     DATA POINT         TEST CELL                   021135
 1/20/77                 021135             1                           021135
INSTRUMENT OPERATOR                         TEST OPERATOR               021135
TREMBLEY                                    EHARDT                      021135
ENGINE MANUFACTURER      MODEL              SERIAL NUMBER               021135
LYCOMING                 ALF-502            LF04                        021135
FUEL IDENT.              FUEL FLOW PPH      MANIFOLD FUEL TEMP FAH      021135
JET-A HC RATIO 0.160      339.              225.5                       021135
ORIFICE AIRFLOW LB/SEC   PT3 PSIA           TT3 DEG.RANKINE             021135
  7.4                     35.1              658.8                       021135
SIMULATED THRUST LBS     FUEL-AIR RATIO MEAS.                           021135
 400.0                   0.0127                                         021135
SIMULATED INLET PRESSURE PO PSIA                                        021135
14.696                                                                  021135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                              021135
498.7                                                                   021135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                     021135
 24.9                                                                   021135
FILTER AREA .365 ST                                                     021135
CLEAN CK SMOKE NUMBER 0                                                 021135
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM  PRESS.-PSIA  TEMP. DEG.FAH 021135
      2.3                 3.0        0.50      11.360          74.0     021135
      2.3                 4.0        0.50      11.310          74.0     021135
      2.3                 7.0        0.52      11.360          74.0     021135
      4.5                11.0        0.50      11.360          75.0     021135
GASEOUS EMISSIONS                                                       021135
                    FID       NDIR      NDIR       CHEMI     CHEMI      021135
RANGE               UHC       CO        CO2        NO        NOX        021135
INSTR GAS TEMP      2         3         2          1         1          021135
RAW VALUE MV        153.      55.       55.        64.       64.        021135
GAS CONCEN PPM(C)   30.6      468.6     573.7      415.8     914.5      021135
GAS CONCEN PCT      240.5     635.2     25627.5    10.3      22.6       021135
EMISSION INDEX      0.0240    0.0635    2.5627     0.0010    0.0023     021135
FUEL-AIR RATIO      9.07      48.2      3054.      1.3       2.8        021135
                    0.0129                                              021135
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COMBUSTOR RIG TEST                                                          061135
DATE                          DATA POINT                TEST CELL           061135
 1/20/77                      061135                    1                   061135
INSTRUMENT OPERATOR                                     TEST OPERATOR       061135
TREMBLEY                                                EHARDT              061135
ENGINE MANUFACTURER           MODEL                     SERIAL NUMBER       061135
LYCOMING                      ALF-502                   LF04                061135
FUEL IDENT.                   FUEL FLOW PPH             MANIFOLD FUEL TEMP FAH 061135
JET-A HC RATIO 0.160           339.                     223.9               061135
ORIFICE AIRFLOW LB/SEC        PT3 PSIA                  TT3 DEG.RANKINE     061135
  7.3                          35.1                     659.7               061135
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                          061135
 400.0                        0.0129                                        061135
SIMULATED INLET PRESSURE P0 PSIA                                            061135
14.696                                                                      061135
SIMULATED INLET TEMPERATURE T0 DEG.RANKINE                                  061135
498.7                                                                       061135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         061135
 33.7                                                                       061135
FILTER AREA .385 SI                                                         061135
CLEAN CK SMOKE NUMBER 0                                                     061135
SMOKE NUMBER         VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH     061135
        2.3                 3.0          0.50     11.310            76.0    061135
        2.3                 4.0          0.52     11.360            76.0    061135
        2.3                 7.0          0.50     11.360            76.0    061135
        6.7                11.0          0.50     11.340            77.0    061135
GASEOUS EMISSIONS                                                           061135
                     FID        NDIR        NDIR       CHEMI      CHEMI     061135
                     UHC         CO          CO2        NO         NOX      061135
RANGE                 2          3           2          1          1        061135
INSTR GAS TEMP       153.       57.         57.        64.        64.       061135
RAW VALUE MV          27.6      450.1       576.1      429.0      915.2     061135
GAS CONCEN PPM(C)    216.4       598.5      25752.1      10.6       22.6    061135
GAS CONCEN PCT       0.0216     0.0599      2.5752     0.0011     0.0023    061135
EMISSION INDEX        8.15       45.3       3062.        1.3        2.8     061135
FUEL-AIR RATIO       0.0129                                                 061135
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COMBUSTOR RIG TEST
DATE                                                              201145
 1/20/77                    DATA POINT          TEST CELL         201145
                            201145              1                 201145
INSTRUMENT OPERATOR                                               201145
TREMBLEY                                        TEST OPERATOR     201145
ENGINE MANUFACTURER                             EBARDT            201145
LYCOMING                    MODEL               SERIAL NUMBER     201145
FUEL IDENT.                 ALF-502             LF04              201145
JET-A HC RATIO 0.160        FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH  201145
ORIFICE AIRFLOW LB/SEC       302.               225.6             201145
  6.3                       PT3 PSIA            TT3 DEG.RANKINE   201145
SIMULATED THRUST LBS         30.5               683.7             201145
 400.0                      FUEL-AIR RATIO MEAS.                  201145
SIMULATED INLET PRESSURE PO PSIA                                  201145
12.761                                                            201145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                        201145
518.7                                                             201145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                               201145
 53.3                                                             201145
FILTER AREA .385 SI                                               201145
CLEAN CK SMOKE NUMBER 0                                           201145
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA   TEMP. DEG.FAH  201145
        0.0               3.0           0.50    11.360          77.0  201145
        0.0               4.0           0.50    11.320          77.0  201145
        2.3               7.0           0.48    11.320          77.0  201145
        2.3              11.0           0.50    11.320          77.0  201145
GASEOUS EMISSIONS                                                 201145
                   FID        NDIR       NDIR       CHEMI      CHEMI  201145
                   UHC         CO         CO2        NO         NOX   201145
RANGE               2          3          2          1          1     201145
INSTR GAS TEMP     153.       56.        56.        64.        64.    201145
RAW VALUE MV        23.7      437.3      575.4      444.0      871.0  201145
GAS CONCEN PPM(C)  185.7       573.7      25918.1      11.0       21.6  201145
GAS CONCEN PCT     0.0186     0.0574     2.5918     0.0011     0.0022  201145
EMISSION INDEX      6.56       43.2      3069.         1.4        2.7  201145
FUEL-AIR RATIO     0.0130                                         201145
                                                                  201145
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COMBUSTOR RIG TEST                                                              031135
DATE                       DATA POINT          TEST CELL                        031135
 1/20/77                   031135              1                                031135
INSTRUMENT OPERATOR                            TEST OPERATOR                    031135
TREMBLEY                                       EHARDT                           031135
ENGINE MANUFACTURER        MODEL               SERIAL NUMBER                    031135
LYCOMING                   ALF-502             LF04                             031135
FUEL IDENT.                FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH           031135
JET-A HC RATIO 0.160         349.              225.3                            031135
ORIFICE AIRFLOW LB/SEC     PT3 PSIA            TT3 DEG.RANKINE                  031135
  7.2                        35.2              686.1                            031135
SIMULATED THRUST LBS       FUEL-AIR RATIO MEAS.                                 031135
 400.0                     0.0135                                               031135
SIMULATED INLET PRESSURE PO PSIA                                                031135
14.696                                                                          031135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                      031135
518.7                                                                           031135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             031135
 24.6                                                                           031135
FILTER AREA .385 SI                                                             031135
CLEAN CK SMOKE NUMBER 0                                                         031135
SMOKE NUMBER         VOL.-LITERS      FLOW-CFM PRESS.-PSIA   TEMP. DEG.FAH      031135
        2.3                  3.0          0.50      11.310            76.0      031135
        0.0                  4.0          0.50      11.310            76.0      031135
        2.3                  7.0          0.50      11.310            76.0      031135
        4.5                 11.0          0.50      11.310            76.0      031135
 GASEOUS EMISSIONS                                                              031135
                    FID        NDIR        NDIR        CHEMI      CHEMI         031135
                    UHC         CO         CO2          NO         NOX          031135
                     2          3           2           1           2           031135
 RANGE             153.        58.         58.         64.         64.          031135
 INSTR GAS TEMP     19.0       413.8       594.7       562.1       270.3        031135
 RAW VALUE MV      149.4       533.3     26826.4        13.9        26.7        031135
 GAS CONCEN PPM(C) 0.0149      0.0533      2.6826      0.0014      0.0027       031135
 GAS CONCEN PCT     5.43        39.0       3080.         1.7         3.2        031135
 EMISSION INDEX    0.0134
 FUEL-AIR RATIO
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COMBUSTOR RIG TEST                                                                  C71145
DATE                           DATA POINT            TEST CELL                      C71145
 1/20/77                       C71145                1                              C71145
INSTRUMENT OPERATOR                                  TEST OPERATOR                  C71145
TREMBLEY                                             EHARCT                         C71145
ENGINE MANUFACTURER            MODEL                 SERIAL NUMBER                  C71145
LYCOMING                       ALF-502               LFC4                           C71145
FUEL IDENT.                    FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH         C71145
JET-A HC RATIO 0.160            348.                 225.5                          C71145
ORIFICE AIRFLOW LB/SEC         PT3 PSIA              TT3 DEG.RANKINE                C71145
  7.0                           35.1                 685.6                          C71145
SIMULATED THRUST LBS           FUEL-AIR RATIO MEAS.                                 C71145
 400.0                         0.0137                                               C71145
SIMULATED INLET PRESSURE PO PSIA                                                    C71145
14.696                                                                              C71145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                          C71145
518.7                                                                               C71145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 C71145
 52.4                                                                               C71145
FILTER AREA .385 SI                                                                 C71145
CLEAN CK SMOKE NUMBER 0                                                             C71145
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              C71145
        2.3                3.0         0.50     11.260             78.0             C71145
        2.3                4.0         0.48     11.260             78.0             C71145
        4.5                7.0         0.50     11.310             77.0             C71145
        4.5               11.0         0.50     11.360             78.0             C71145
GASEOUS EMISSIONS                                                                   C71145
                   FID       NDIR       NDIR      CHEMI     CHEMI                   C71145
                   UHC        CO         CO2       NO        NOX                    C71145
RANGE               2          3          2         1         1                     C71145
INSTR GAS TEMP     153.       60.        60.       65.       65.                    C71145
RAW VALUE MV        19.5      403.1      556.5     534.3     1007.6                 C71145
GAS CONCEN PPM(C)  153.7      518.0     27072.7     13.1       24.7                 C71145
GAS CONCEN PCT     0.0154     0.0518     2.7073    0.0013     0.0025                C71145
EMISSION INDEX      5.54      37.5      3082.         1.6        2.9                C71145
FUEL-AIR RATIO     0.0135                                                           C71145
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COMBUSTOR RIG TEST                                                       101145
DATE                         CATA PCINT            TEST CELL             101145
 1/20/77                     101145                1                     1C1145
INSTRUMENT OPERATCR                                TEST OPERATCR         1C1145
TREMBLEY                                           EHARDT                1C1145
ENGINE MANUFACTURER          MODEL                 SERIAL NUMBER         1C1145
LYCOMING                     ALF-5C2               LFC4                  1C1145
FUEL IDENT.                  FUEL FLCW PPH         MANIFOLC FUEL TEMP FAH 1C1145
JET-A HC RATIO C.160          348.                 225.7                 101145
ORIFICE AIRFLOW LB/SEC       PT3 PSIA              TT3 DEG.RANKINE       101145
  7.5                         35.1                 686.5                 101145
SIMULATED THRUST LBS         FUEL-AIR RATIC MEAS.                        101145
 400.0                       0.0128                                      101145
SIMULATED INLET PRESSURE PC PSIA                                         101145
14.696                                                                   1C1145
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                               1C1145
518.7                                                                    101145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                      101145
 64.4                                                                    101145
FILTER AREA .385 SI                                                      1C1145
CLEAN CK SMCKE NUMBER 0                                                  1C1145
SMOKE NUMBER      VCL.-LITERS     FLCW-CFM PRESS.-PSIA   TEMP. DEG.FAH   1C1145
      0.0                3.0          C.50       11.380           78.0   1C1145
      0.0                4.C          C.50       11.38C           78.C   101145
      0.0                7.C          C.50       11.38C           78.C   101145
      0.0               11.C          C.50       11.380           79.0   101145
GASEOUS EMISSICNS                                                        101145
                 FID        NDIR        NCIR        CHEMI       CHEMI    1C1145
                 UHC         CO          CC2         NC          NCX     101145
RANGE             2          3           2           1           1       1C1145
INSTR GAS TEMP   153.       62.         62.         65.         64.      1C1145
RAW VALUE MV      2C.8      404.7       573.6       483.2       916.3    101145
GAS CONCEN PPM(C) 164.3      526.3       25913.5       12.0        22.6  101145
GAS CONCEN PCT   C.C164     C.0526      2.5913      0.0C12      0.0023   1C1145
EMISSION INDEX    6.18       39.8       3077.          1.5         2.8   101145
FUEL-AIR RATIC   0.0130                                                  101145
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COMBUSTOR RIG TEST
DATE                                  DATA POINT           TEST CELL                   161145
 1/21/77                              161145               1                           161145
INSTRUMENT OPERATOR                                                                    161145
TREMBLEY                                                   TEST OPERATOR               161145
ENGINE MANUFACTURER                   MODEL                EHARDT                      161145
LYCOMING                              ALF-502              SERIAL NUMBER               161145
FUEL IDENT.                           FUEL FLOW PPH        LF04                        161145
JET-A HC RATIO 0.158                   376.                MANIFOLD FUEL TEMP FAH      161145
ORIFICE AIRFLOW LB/SEC                PT3 PSIA             226.2                       161145
  8.0                                  37.9                TT3 DEG.RANKINE             161145
SIMULATED THRUST LBS                  FUEL-AIR RATIO MEAS. 686.5                       161145
 400.0                                0.0131                                           161145
SIMULATED INLET PRESSURE PO PSIA                                                       161145
15.855                                                                                 161145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                             161145
518.7                                                                                  161145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                    161145
 50.2                                                                                  161145
FILTER AREA .385 SI                                                                    161145
CLEAN CK SMOKE NUMBER 0                                                                161145
SMOKE NUMBER          VOL.-LITERS       FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH            161145
         0.0                  3.0           0.50     11.460              72.0          161145
         0.0                  4.0           0.50     11.410              72.0          161145
         2.3                  7.0           0.50     11.410              72.0          161145
         4.5                 11.0           0.48     11.380              72.0          161145
GASEOUS EMISSIONS                                                                      161145
                   FID        NDIR         NDIR        CHEMI       CHEMI               161145
                   UHC         CO          CO2          NO          NOX                161145
RANGE               2          3            2           1           2                  161145
INSTR GAS TEMP     153.       55.          55.         64.         64.                 161145
RAW VALUE MV        18.7      403.7        597.4       531.7       259.4               161145
GAS CONCEN PPM(C)   146.5      507.9        26485.3        12.9        25.3            161145
GAS CONCEN PCT     0.0147     0.0508       2.6485      0.0013      0.0025              161145
EMISSION INDEX      5.40       37.7        3088.           1.6         3.1             161145
FUEL-AIR RATIO     0.0132                                                              161145
                                                                                       161145
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COMBUSTOR RIG TEST                                                              192135
DATE                       DATA POINT            TEST CELL                      192135
 1/21/77                   192135                1                              192135
INSTRUMENT OPERATOR                              TEST OPERATOR                  192135
TREMBLEY                                         EHARDT                         192135
ENGINE MANUFACTURER        MODEL                 SERIAL NUMBER                  192135
LYCOMING                   ALF-502               LF04                           192135
FUEL IDENT.                FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH         192135
JET-A HC RATIO 0.158        343.                 226.7                          192135
ORIFICE AIRFLOW LB/SEC     FT3 PSIA              TT3 DEG.RANKINE                192135
  9.6                       34.9                 689.6                          192135
SIMULATED THRUST LBS       FUEL-AIR RATIO MEAS.                                 192135
 600.0                     0.0099                                               192135
SIMULATED INLET PRESSURE PO PSIA                                                192135
12.761                                                                          192135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                      192135
478.7                                                                           192135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             192135
 24.8                                                                           192135
FILTER AREA .385 SI                                                             192135
CLEAN CK SMOKE NUMBER 0                                                         192135
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          192135
        0.0                3.0          0.50     11.440              71.0       192135
        0.0                4.0          0.50     11.440              71.0       192135
        2.3                7.0          0.48     11.370              71.0       192135
        2.3               11.0          0.50     11.390              71.0       192135
GASEOUS EMISSIONS                                                               192135
                   FID        NDIR       NDIR       CHEMI      CHEMI            192135
                   UHC         CO         CO2        NO         NOX             192135
RANGE               2          3          2          1          1               192135
INSTR GAS TEMP     153.       52.        52.        63.        63.              192135
RAW VALUE MV        26.7      442.3      450.2      284.8      646.8            192135
GAS CONCEN PPM(C)  210.0       579.2    19254.3        6.9        15.7          192135
GAS CONCEN PCT     0.0210     0.0579     1.9254     0.0007     0.0016           192135
EMISSION INDEX     10.48       58.2     3040.          1.1        2.6           192135
FUEL-AIR RATIO     0.0097                                                       192135
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COMBUSTOR RIG TEST
DATE                                                                        012135
 1/21/77                      DATA POINT            TEST CELL               012135
                              012135                1                       012135
INSTRUMENT OPERATOR                                 TEST OPERATOR           012135
TREMBLEY                                            EHARDT                  012135
ENGINE MANUFACTURER           MODEL                 SERIAL NUMBER           012135
LYCOMING                      ALF-502               LF04                    012135
FUEL IDENT.                   FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH  012135
JET-A HC RATIO 0.158           395.                 222.7                   012135
ORIFICE AIRFLOW LB/SEC        PT3 PSIA              TT3 DEG.RANKINE         012135
 10.8                          40.1                 691.2                   012135
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                          012135
 600.0                        0.0101                                        012135
SIMULATED INLET PRESSURE PO PSIA                                            012135
14.696                                                                      012135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                  012135
478.7                                                                       012135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         012135
 24.9                                                                       012135
FILTER AREA .385 SI                                                         012135
CLEAN CK SMOKE NUMBER 0                                                     012135
SMOKE NUMBER      VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH        012135
        0.0                3.0        0.50      11.440             72.0     012135
        2.3                4.0        0.48      11.360             72.0     012135
        2.3                7.0        0.50      11.390             72.0     012135
        2.3               11.0        0.50      11.390             72.0     012135
GASEOUS EMISSIONS                                                           012135
                   FID       NDIR      NDIR      CHEMI     CHEMI            012135
                   UHC       CO        CO2       NO        NOX              012135
RANGE               2        3         2         1         1                012135
INSTR GAS TEMP     153.      56.       56.       63.       63.              012135
RAW VALUE MV        23.1     413.3     466.0     331.1     732.6            012135
GAS CONCEN PPM(C)  181.7     531.2     20080.8      8.2       17.7          012135
GAS CONCEN PCT     0.0182    0.0531    2.0081    0.0008    0.0018           012135
EMISSION INDEX     8.74      51.4      3056.       1.3       2.8            012135
FUEL-AIR RATIO     0.0101                                                   012135
                                                                            012135
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COMBUSTOR RIG TEST
DATE
 3/ 3/77                        DATA POINT               TEST CELL                       152135
INSTRUMENT OPERATOR             152135                   1                               152135
TREMBLEY                                                 TEST OPERATOR                   152135
ENGINE MANUFACTURER                                      EHARDT                          152135
LYCOMING                        MODEL                    SERIAL NUMBER                   152135
FUEL IDENT.                     ALF-502                  LFC4                            152135
JET-A HC RATIO 0.158            FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH          152135
ORIFICE AIRFLOW LB/SEC           424.                    188.8                           152135
 11.6                           PT3 PSIA                 T13 DEG.RANKINE                 152135
SIMULATED THRUST LBS             43.3                    707.1                           152135
 600.0                          FUEL-AIR RATIO MEAS.                                     152135
SIMULATED INLET PRESSURE PO PSIA 0.0101                                                  152135
15.855                                                                                   152135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                               152135
478.7                                                                                    152135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                      152135
 28.1                                                                                    152135
FILTER AREA .385 SI                                                                      152135
CLEAN CK SMOKE NUMBER 0                                                                  152135
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM  PRESS.-PSIA   TEMP. DEG.FAH                 152135
         2.3                3.0        0.48       11.362            77.0                 152135
         4.5                4.0        0.50       11.362            77.0                 152135
         2.3                7.0        0.50       11.362            77.0                 152135
         8.8               11.0        0.50       11.411            77.0                 152135
GASEOUS EMISSIONS                                                                        152135
                    FID        NDIR       NDIR       CHEMI      CHEMI                    152135
                    UHC        CO         CO2        NO         NOX                      152135
RANGE               2          3          2          1          1                        152135
INSTR GAS TEMP      194.       45.        45.        64.        64.                      152135
RAW VALUE MV         16.3      390.9      465.2      391.0      781.6                    152135
GAS CONCEN PPM(C)   142.8      478.1      20073.1      8.3        18.6                   152135
GAS CONCEN PCT      0.0143     0.0478     2.0073     0.0008     0.0019                   152135
EMISSION INDEX      6.90       46.5       3069.        1.3        3.0                    152135
FUEL-AIR RATIO      0.0100                                                               152135
                                                                                         152135
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COMBUSTOR RIG TEST                                                       022135
DATE                      DATA POINT            TEST CELL                022135
 1/21/77                  022135                1                        022135
INSTRUMENT OPERATOR                             TEST OPERATOR            022135
TREMBLEY                                        EHARDT                   022135
ENGINE MANUFACTURER       MODEL                 SERIAL NUMBER            022135
LYCOMING                  ALF-502               LF04                     022135
FUEL IDENT.               FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH   022135
JET-A HC RATIO 0.158       405.                 224.8                    022135
ORIFICE AIRFLOW LB/SEC    PT3 PSIA              TT3 DEG.RANKINE          022135
 10.8                      40.1                 717.8                    022135
SIMULATED THRUST LBS      FUEL-AIR RATIO MEAS.                           022135
 600.0                    0.0104                                         022135
SIMULATED INLET PRESSURE P0 PSIA                                         022135
14.696                                                                   022135
SIMULATED INLET TEMPERATURE T0 DEG.RANKINE                               022135
498.7                                                                    022135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                      022135
 24.6                                                                    022135
FILTER AREA .385 SI                                                      022135
CLEAN CK SMOKE NUMBER 0                                                  022135
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   022135
        0.0                 3.0        0.50     11.380            74.0   022135
        0.0                 4.0        0.50     11.380            74.0   022135
        2.3                 7.0        0.50     11.430            75.0   022135
        2.3                11.0        0.50     11.380            75.0   022135
GASEOUS EMISSIONS                                                        022135
                    FID        NDIR       NDIR       CHEMI      CHEMI    022135
                    UHC         CO         CO2        NO         NOX     022135
RANGE                2          3          2          1          1       022135
INSTR GAS TEMP      153.       54.        54.        64.        64.      022135
RAW VALUE MV         18.8      405.7      481.0      406.0      810.4    022135
GAS CONCEN PPM(C)    147.2      517.3     20806.1      10.0       19.6   022135
GAS CONCEN PCT      0.0147     0.0517     2.0806     0.0010     0.0020   022135
EMISSION INDEX        6.85      48.5      3066.        1.5        3.0    022135
FUEL-AIR RATIO      0.0104                                               022135
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COMBUSTOR RIG TEST                                                          062145
DATE                          DATA POINT          TEST CELL                 062145
 1/21/77                      062145              1                         062145
INSTRUMENT OPERATOR                               TEST OPERATOR             062145
TREMBLEY                                          EHARDT                    062145
ENGINE MANUFACTURER           MODEL               SERIAL NUMBER             062145
LYCOMING                      ALF-502             LF04                      062145
FUEL IDENT.                   FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH    062145
JET-A HC RATIO 0.158           405.               224.7                     062145
ORIFICE AIRFLOW LB/SEC        PT3 PSIA            TT3 DEG.RANKINE           062145
 10.8                          40.2               717.9                     062145
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                          062145
 600.0                        0.0105                                        062145
SIMULATED INLET PRESSURE PC PSIA                                            062145
14.696                                                                      062145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                  062145
498.7                                                                       062145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         062145
 33.5                                                                       062145
FILTER AREA .385 SI                                                         062145
CLEAN CK SMOKE NUMBER 0                                                     062145
SMOKE NUMBER      VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       062145
        2.3               3.0         0.50     11.430            76.0       062145
        2.3               4.0         0.48     11.380            76.0       062145
        2.3               7.0         0.50     11.380            76.0       062145
        2.3              11.0         0.50     11.410            76.0       062145
GASEOUS EMISSIONS                                                           062145
                 FID       NDIR       NDIR       CHEMI       CHEMI          062145
                 UHC        CO         CO2        NO          NOX           062145
RANGE             2          3          2          1           1            062145
INSTR GAS TEMP   153.       53.        53.        63.         63.           062145
RAW VALUE MV      19.0     406.2      483.4      402.2       793.6          062145
GAS CONCEN PPM(C) 149.0     518.2    20921.9        9.9         19.2        062145
GAS CONCEN PCT   0.0149    0.0518     2.0922     0.0010      0.0019         062145
EMISSION INDEX    6.90      48.3      3066.         1.5         2.9         062145
FUEL-AIR RATIO   0.0105                                                     062145
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COMBUSTOR RIG TEST                                                             041135
DATE                           DATA POINT             TEST CELL                041135
 1/21/77                       041135                 1                        C41135
INSTRUMENT OPERATOR                                   TEST OPERATOR            C41135
TREMBLEY                                              EHARDT                   041135
ENGINE MANUFACTURER            MODEL                  SERIAL NUMBER            041135
LYCOMING                       ALF-502                LF04                     C41135
FUEL IDENT.                    FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH   041135
JET-A HC RATIO 0.158            360.                  227.7                    041135
ORIFICE AIRFLOW LB/SEC         PT3 PSIA               TT3 DEG.RANKINE          C41135
  7.0                           35.0                  720.3                    041135
SIMULATED THRUST LBS           FUEL-AIR RATIO MEAS.                            C41135
 400.0                         0.0143                                          C41135
SIMULATED INLET PRESSURE PO PSIA                                               C41135
14.696                                                                         041135
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                     C41135
544.7                                                                          041135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                            C41135
 24.7                                                                          041135
FILTER AREA .385 SI                                                            C41135
CLEAN CK SMOKE NUMBER 0                                                        C41135
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH         041135
       2.3                 3.0         0.50     11.430           74.0          041135
       2.3                 4.0         0.50     11.430           74.0          C41135
       2.3                 7.0         0.52     11.390           75.0          C41135
       2.3                11.0         0.50     11.390           75.0          041135
GASEOUS EMISSIONS                                                              041135
                 FID       NDIR       NDIR       CHEMI      CHEMI              C41135
                 UHC        CO        CO2         NO         NOX               041135
RANGE             2          2          2          1          2                041135
INSTR GAS TEMP   153.       55.        55.        63.        63.               C41135
RAW VALUE MV     12.1      502.1      645.6      772.5      313.1              041135
GAS CONCEN PPM(C) 93.8     450.1    29055.3       18.7       30.0              C41135
GAS CONCEN PCT   0.0094    0.0450    2.9055     0.0019     0.0030              041135
EMISSION INDEX   3.17       30.6      3106.        2.1        3.4              C41135
FUEL-AIR RATIO   0.0144                                                        C41135
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COMBUSTOR RIG TEST                                                       C81145
DATE                        DATA POINT          TEST CELL                C81145
 1/21/77                    C81145              1                        C81145
INSTRUMENT OPERATOR                             TEST OPERATOR            C81145
TREMBLEY                                        EHARCT                   C81145
ENGINE MANUFACTURER         MODEL               SERIAL NUMBER            C81145
LYCOMING                    ALF-502             LF04                     C81145
FUEL IDENT.                 FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH   C81145
JET-A HC RATIO 0.158         360.               225.2                    C81145
ORIFICE AIRFLOW LB/SEC      FT3 PSIA            TT3 DEG.RANKINE          C81145
  6.9                        35.0               719.0                    C81145
SIMULATED THRUST LBS        FUEL-AIR RATIO MEAS.                         C81145
 400.0                      0.0145                                       C81145
SIMULATED INLET PRESSURE PO PSIA                                         C81145
14.696                                                                   C81145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                               C81145
544.7                                                                    C81145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                      C81145
 51.4                                                                    C81145
FILTER AREA .385 SI                                                      C81145
CLEAN CK SMOKE NUMBER 0                                                  C81145
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM  PRESS.-PSIA  TEMP. DEG.FAH  C81145
      0.0                 3.0          0.50       11.430           73.0  C81145
      0.0                 4.0          0.50       11.390           73.0  C81145
      2.3                 7.0          0.50       11.430           73.0  C81145
      2.3                11.0          0.50       11.390           74.0  C81145
GASEOUS EMISSIONS                                                        C81145
                                                                         C81145
                    FID       NDIR       NDIR       CHEMI     CHEMI      C81145
RANGE               UHC       CO         CO2        NO        NOX        C81145
INSTR GAS TEMP      1         2          2          1         2          C81145
RAW VALUE MV        153.      54.        54.        64.       63.        C81145
GAS CONCEN PPM(C)   122.0     877.3      646.2      721.2     293.7      C81145
GAS CONCEN PCT        95.6      435.2     29088.8      17.4      28.1    C81145
EMISSION INDEX      0.0096    0.0435     2.9089     0.0017    0.0028     C81145
FUEL-AIR RATIO      3.23      29.6       3107.         1.9       3.1     C81145
                    0.0144
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COMBUSTOR RIG TEST
DATE
 1/21/77                     DATA POINT           TEST CELL               111145
INSTRUMENT OPERATOR          111145               1                       111145
TREMBLEY                                          TEST OPERATOR           111145
ENGINE MANUFACTURER          MODEL                EHARDT                  111145
LYCOMING                     ALF-502              SERIAL NUMBER           111145
FUEL IDENT.                  FUEL FLOW PPH        LFC4                    111145
JET-A HC RATIO 0.158          360.                MANIFOLD FUEL TEMP FAH  111145
ORIFICE AIRFLOW LB/SEC       PT3 PSIA             224.6                   111145
  6.8                         35.1                TT3 DEG.RANKINE         111145
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS. 718.8                   111145
 400.0                       0.0147                                       111145
SIMULATED INLET PRESSURE PC PSIA                                          111145
14.696                                                                    111145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                111145
544.7                                                                     111145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                       111145
101.7                                                                     111145
FILTER AREA .385 SI                                                       111145
CLEAN CK SMOKE NUMBER 0                                                   111145
SMOKE NUMBER         VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   111145
       0.0                 3.0         0.50     11.430         73.0       111145
       2.3                 4.0         0.50     11.430         73.0       111145
       2.3                 7.0         0.50     11.390         73.0       111145
       2.3                11.0         0.50     11.430         73.0       111145
GASEOUS EMISSIONS                                                         111145
                   FID        NDIR       NDIR                             111145
RANGE              UHC        CO         CO2        CHEMI     CHEMI       111145
INSTR GAS TEMP      2          2          2          NO        NOX        111145
RAW VALUE MV       153.       52.         2          1         2          111145
GAS CONCEN PPM(C)   13.6     667.0       52.        63.       63.         111145
GAS CONCEN PCT     106.3      441.0     649.0      646.0     256.2        111145
EMISSION INDEX    0.0106     0.0441   29229.3       15.6      24.7        111145
FUEL-AIR RATIO      3.57      29.8     2.9229     0.0016    0.0025        111145
                  0.0145              3106.         1.7       2.7         111145
                                                                          111145
                                                                          111145
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COMBUSTOR RIG TEST                                                                   131145
DATE                                                                                  131145
 1/21/77                     DATA POINT            TEST CELL                          131145
INSTRUMENT OPERATOR          131145                1                                  131145
TREMBLEY                                           TEST OPERATOR                      131145
ENGINE MANUFACTURER                                EHARDT                             131145
LYCOMING                     MODEL                 SERIAL NUMBER                      131145
FUEL IDENT.                  ALF-502               LF04                               131145
JET-A HC RATIO 0.158         FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH             131145
ORIFICE AIRFLOW LB/SEC        360.                 225.0                              131145
  6.7                        FT3 PSIA              TT3 DEG.RANKINE                    131145
SIMULATED THRUST LBS          35.0                 723.4                              131145
 400.0                       FUEL-AIR RATIO MEAS.                                     131145
SIMULATED INLET PRESSURE P0 PSIA                                                      131145
14.696                       0.0150                                                   131145
SIMULATED INLET TEMPERATURE T0 DEG.RANKINE                                            131145
544.7                                                                                 131145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                   131145
166.8                                                                                 131145
FILTER AREA .385 SI                                                                   131145
CLEAN CK SMOKE NUMBER 0                                                               131145
SMOKE NUMBER         VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              131145
         0.0                3.0          0.50    11.390               71.0            131145
         0.0                4.0          0.50    11.390               71.0            131145
         7.3                7.0          0.48    11.340               72.0            131145
         2.3               11.0          0.48    11.340               72.0            131145
GASEOUS EMISSIONS                                                                     131145
                     FID         NDIR        NDIR        CHEMI       CHEMI            131145
                     UHC         CO          CO2         NO          NOX              131145
RANGE                 2           2           2          1            1               131145
INSTR GAS TEMP       153.        55.         55.         63.         63.              131145
RAW VALUE MV          18.1       531.2       653.4       544.3       860.1            131145
GAS CONCEN PPM(C)    142.0        465.3      29386.9        13.5         21.1         131145
GAS CONCEN PCT       0.0142      0.0465      2.9387      0.0014      0.0021           131145
EMISSION INDEX        4.73        31.2       3100.          1.5          2.3          131145
FUEL-AIR RATIO       0.0146                                                           131145
                                                                                      131145
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COMBUSTOR RIG TEST
DATE
 1/21/77                      DATA POINT           TEST CELL             202145
INSTRUMENT OPERATOR           202145               1                     202145
TREMBLEY                                           TEST OPERATOR         202145
ENGINE MANUFACTURER                                EHARDT                202145
LYCOMING                      MODEL                SERIAL NUMBER         202145
FUEL IDENT.                   ALF-502              LFC4                  202145
JET-A HC RATIO 0.158          FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH 202145
ORIFICE AIRFLOW LB/SEC         362.                226.4                 202145
  9.1                         PT3 PSIA             TT3 DEG.RANKINE       202145
SIMULATED THRUST LBS           34.9                745.8                 202145
 600.0                        FUEL-AIR RATIO MEAS.                       202145
                              0.0110                                     202145
SIMULATED INLET PRESSURE PO PSIA                                         202145
12.761                                                                   202145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                               202145
518.7                                                                    202145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                      202145
 48.7                                                                    202145
FILTER AREA .385 SI                                                      202145
CLEAN CK SMOKE NUMBER 0                                                  202145
SMOKE NUMBER       VOL.-LITERS   FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH     202145
          2.3            3.0         0.50    11.440            72.0      202145
          0.0            4.0         0.50    11.440            72.0      202145
          2.3            7.0         0.52    11.440            72.0      202145
          2.3           11.0         0.52    11.440            72.0      202145
GASEOUS EMISSIONS                                                        202145
                    FID       NDIR       NDIR      CHEMI     CHEMI       202145
RANGE               UHC        CO         CO2       NO        NOX        202145
                     2          3          2         1         1         202145
INSTR GAS TEMP      153.       52.        52.       63.       63.        202145
RAW VALUE MV         19.7     427.8      504.0     417.3     787.3       202145
GAS CONCEN PPM(C)   154.6     556.3    21900.0      10.5      19.3       202145
GAS CONCEN PCT      0.0155    0.0556     2.1908    0.0010    0.0019      202145
EMISSION INDEX       6.84      49.5      3065.       1.5       2.8       202145
FUEL-AIR RATIO      0.0110                                               202145
                                                                         202145
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COMBUSTOR RIG TEST                                                                  032135
DATE                          DATA POINT            TEST CELL                       032135
 1/24/77                      032135                1                               032135
INSTRUMENT OPERATOR                                                                 032135
TREMBLEY                                            TEST OPERATOR                   032135
ENGINE MANUFACTURER                                 EHARDT                          032135
LYCOMING                      MODEL                 SERIAL NUMBER                   032135
FUEL IDENT.                   ALF-502               LF04                            032135
JET-A HC RATIO 0.158          FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH          032135
                               418.                 226.4                           032135
ORIFICE AIRFLOW LB/SEC        PT3 PSIA              TT3 DEG.RANKINE                 032135
 10.5                          40.3                 747.1                           032135
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                                  032135
 600.0                        0.0110                                                032135
SIMULATED INLET PRESSURE PO PSIA                                                    032135
14.696                                                                              032135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                          032135
518.7                                                                               032135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 032135
 24.5                                                                               032135
FILTER AREA .385 SI                                                                 032135
CLEAN-CK SMOKE NUMBER 0                                                             032135
SMOKE NUMBER       VOL.-LITERS       FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH            032135
        0.0                3.0            0.50     11.610              72.0         032135
        2.3                4.0            0.50     11.610              72.0         032135
        0.0                7.0            0.50     11.610              71.0         032135
        0.0               11.0            0.50     11.560              71.0         032135
GASEOUS EMISSIONS                                                                   032135
                   FID        NDIR       NDIR       CHEMI      CHEMI                032135
                   UHC         CO         CO2        NO         NOX                 032135
RANGE               2          3          2          1          1                   032135
INSTR GAS TEMP     153.       55.        55.        64.        64.                  032135
RAW VALUE MV        15.8      413.0      501.6      491.3      911.4                032135
GAS CONCEN PPM(C)  124.4       528.0     22057.3       11.9       22.1              032135
GAS CONCEN PCT     0.0124     0.0528     2.2057     0.0012     0.0022               032135
EMISSION INDEX       5.48      46.8      3073.         1.7        3.2               032135
FUEL-AIR RATIO     0.0110                                                           032135
                                                                                    032135
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COMBUSTOR RIG TEST                                                                C72145
DATE                          CATA FCINT            TEST CELL                     C72145
 1/24/77                      C72145                1                             C72145
INSTRUMENT OPERATCR                                 TEST OPERATOR                 072145
TREMBLFY                                            EHARCT                        072145
FNGINE MANUFACTURER           MODEL                 SFRIAL NUMBER                 C72145
LYCOMING                      ALF-5C2               LF04                          072145
FUEL IDENT.                   FUEL FLCW PPH         MANIFCLD FUFL TEMP FAH        C72145
JET-A HC RATIO C.158           417.                 225.8                         072145
ORIFICE AIRFLOW LB/SEC        PT3 PSIA              TT3 DEG.RANKINE               072145
 10.4                          40.2                 746.5                         072145
SIMULATED THRUST LBS          FUEL-AIR RATIC MEAS.                                072145
 600.0                        0.0112                                              072145
SIMULATED INLET PRESSLRF PO PSIA                                                  C72145
14.696                                                                            072145
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                        C72145
518.7                                                                             C72145
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                               072145
 51.4                                                                             C72145
FILTER AREA .385 SI                                                               C72145
CLEAN CK SMOKE NUMBER 0                                                           C72145
SMOKE NUMBER          VCL.-LITERS       FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH       C72145
       2.3                    3.0            C.50      11.590            71.0     072145
       2.3                    4.C            C.52      11.540            71.C     C72145
       0.0                    7.C            0.52      11.590            72.C     C72145
       0.0                   11.C            C.50      11.540            73.C     C72145
GASEOUS EMISSICNS                                                                 C72145
                      FIC         NDIR        NCIR        CHEMI       CHEMI       C72145
                      UHC         CO          CC2         NC          NOX         072145
RANGE                  2           3           2           1           1          C72145
INSTR GAS TEMP        153.        54.         54.         64.         63.         C72145
RAW VALUE MV           16.0       406.7       504.1       501.4       849.C       072145
GAS CONCEN PPM(C)      126.0       516.7     22182.9        12.2        20.6      C72145
GAS CONCEN PCT        0.0126      0.0517      2.2183      C.CC12      0.CC21      C72145
EMISSION INDEX         5.52        45.6       3075.          1.8         3.0      C72145
FUEL-AIR RATIO        0.C111                                                      C72145
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COMBUSTOR RIG TEST                                                            102145
DATE                             DATA POINT            TEST CELL              102145
 1/24/77                         102145                1                      102145
INSTRUMENT OPERATOR                                    TEST OPERATOR          102145
TREMBLEY                                               EHARDT                 102145
ENGINE MANUFACTURER              MODEL                 SERIAL NUMBER          102145
LYCOMING                         ALF-502               LF04                   102145
FUEL IDENT.                      FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH 102145
JET-A HC RATIO 0.158              416.                 225.3                  102145
ORIFICE AIRFLOW LB/SEC           PT3 PSIA              TT3 DEG.RANKINE        102145
 10.4                             40.2                 746.9                  102145
SIMULATED THRUST LBS             FUEL-AIR RATIO MEAS.                         102145
 600.0                           0.0111                                       102145
SIMULATED INLET PRESSURE PO PSIA                                              102145
14.696                                                                        102145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                    102145
518.7                                                                         102145
SPECIFIC HUMIDITY GRAINS/LB.DRY AIR                                           102145
 67.0                                                                         102145
FILTER AREA .385 SI                                                           102145
CLEAN CK SMOKE NUMBER 0                                                       102145
SMOKE NUMBER       VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       102145
          2.3              3.0           0.50     11.560             72.0     102145
          0.0              4.0           0.50     11.540             72.0     102145
          0.0              7.0           0.49     11.540             72.0     102145
          0.0             11.0           0.50     11.540             73.0     102145
GASEOUS EMISSIONS                                                             102145
                   FID          NDIR         NDIR        CHEMI      CHEMI     102145
                   UHC          CO           CO2         NO         NOX       102145
RANGE              2            3            2           1          1         102145
INSTR GAS TEMP     153.         52.          52.         64.        64.       102145
RAW VALUE MV        18.8        410.3        502.4       443.5      819.7     102145
GAS CONCEN PPM(C)   148.4        523.1       22098.7        10.8       19.9   102145
GAS CONCEN PCT     0.0148       0.0523       2.2099      0.0011     0.0020    102145
EMISSION INDEX      6.52         46.3        3071.          1.6        2.9    102145
FUEL-AIR RATIO     0.0111                                                     102145
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COMBUSTOR RIG TEST
DATE
 3/ 3/77                        DATA POINT                TEST CELL                    162145
INSTRUMENT OPERATOR             162145                    1                            162145
TREMBLEY                                                  TEST OPERATOR                162145
ENGINE MANUFACTURER                                       EHARDT                       162145
LYCOMING                        MODEL                     SERIAL NUMBER                162145
FUEL IDENT.                     ALF-502                   LF04                         162145
JET-A HC RATIO 0.158            FUEL FLOW PPH             MANIFOLD FUEL TEMP FAH       162145
ORIFICE AIRFLOW LB/SEC           449.                     225.6                        162145
 11.1                           PT3 PSIA                  TT3 DEG.RANKINE              162145
SIMULATED THRUST LBS             43.5                     745.4                        162145
 600.0                          FUEL-AIR RATIO MEAS.                                   162145
SIMULATED INLET PRESSURE PO PSIA 0.0112                                                162145
15.855                                                                                 162145
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                             162145
518.7                                                                                  162145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                    162145
 48.6                                                                                  162145
FILTER AREA .385 SI                                                                    162145
CLEAN CK SMOKE NUMBER 0                                                                162145
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              162145
       0.0                 3.0           0.48     11.411                               162145
       4.5                 4.0           0.50     11.411           75.0                162145
       0.0                 7.0           0.48     11.411           75.0                162145
       4.5                11.0           0.48     11.411           75.0                162145
GASEOUS EMISSIONS                                                  75.0                162145
                    FID        NDIR        NDIR        CHEMI                           162145
                    UHC         CO          CO2         NO          CHEMI              162145
RANGE                2          2           2           1            NOX               162145
INSTR GAS TEMP      153.       56.         56.         64.           1                 162145
RAW VALUE MV         13.3      857.5       516.9       441.7        64.                162145
GAS CONCEN PPM(C)   115.8       451.6       22583.3       11.1      882.0              162145
GAS CONCEN PCT      0.0116     0.0452      2.2583      0.0011         21.9             162145
EMISSION INDEX       5.00       39.3       3087.          1.6       0.0022             162145
FUEL-AIR RATIO      0.0112                                           3.1               162145
                                                                                       162145
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COMBUSTOR RIG TEST                                                               211135
DATE                         DATA POINT          TEST CELL                       211135
 1/25/77                     211135              1                               211135
INSTRUMENT OPERATOR                              TEST OPERATOR                   211135
TREMBLEY                                         EHARDT                          211135
ENGINE MANUFACTURER          MODEL               SERIAL NUMBER                   211135
LYCOMING                     ALF-502             LF04                            211135
FUEL IDENT.                  FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH          211135
JET-A HC RATIO 0.158          322.               224.0                           211135
ORIFICE AIRFLOW LB/SEC       PT3 PSIA            TT3 DEG.RANKINE                 211135
  6.1                         30.5               746.4                           211135
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                                211135
 400.0                       0.0147                                              211135
SIMULATED INLET PRESSURE PC PSIA                                                 211135
12.761                                                                           211135
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                       211135
564.7                                                                            211135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                              211135
 25.9                                                                            211135
FILTER AREA .385 SI                                                              211135
CLEAN CK SMOKE NUMBER 0                                                          211135
SMOKE NUMBER       VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          211135
          0.0               3.0         0.50     11.300             74.0         211135
          0.0               4.0         0.50     11.250             74.0         211135
          0.0               7.0         0.51     11.300             75.0         211135
          2.3              11.0         0.50     11.250             75.0         211135
GASEOUS EMISSIONS                                                                211135
                  FID         NDIR        NDIR        CHEMI      CHEMI           211135
                  UHC          CO          CO2          NO        NOX            211135
RANGE              1           2           2           2          2              211135
INSTR GAS TEMP    153.        58.         58.         64.        64.             211135
RAW VALUE MV      103.8       887.1       653.5       212.6      313.5           211135
GAS CONCEN PPM(C)   82.7      446.4     30103.1        20.6        30.6          211135
GAS CONCEN PCT    0.0083      0.0446      3.0103      0.0021     0.0031          211135
EMISSION INDEX     2.70        29.3       3109.          2.2        3.3          211135
FUEL-AIR RATIO    0.0149                                                         211135
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COMBUSTOR RIG TEST
DATE                                                                  221145
 1/25/77                     DATA POINT        TEST CELL              221145
INSTRUMENT OPERATOR          221145            1                      221145
TREMBLEY                                       TEST OPERATOR          221145
ENGINE MANUFACTURER                            EHARDT                 221145
LYCOMING                     MODEL             SERIAL NUMBER          221145
FUEL IDENT.                  ALF-502           LF04                   221145
JET-A HC RATIO 0.158         FUEL FLOW PPH     MANIFOLD FUEL TEMP FAH 221145
ORIFICE AIRFLOW LB/SEC        322.             224.2                  221145
  5.8                        PT3 PSIA          TT3 DEG.RANKINE        221145
STIMULATED THRUST LBS         30.5             746.9                  221145
 400.0                       FUEL-AIR RATIO MEAS.                     221145
                             0.0154                                   221145
SIMULATED INLET PRESSURE PO PSIA                                      221145
12.761                                                                221145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                            221145
564.7                                                                 221145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                   221145
176.3                                                                 221145
FILTER AREA .385 SI                                                   221145
CLEAN CK SMOKE NUMBER 0                                               221145
SMOKE NUMBER         VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH  221145
      0.0                  3.0          0.50      11.230                 221145
      0.0                  4.0          0.50      11.240         76.0    221145
      0.0                  7.0          0.50      11.240         76.0    221145
      2.3                 11.0          0.48      11.230         76.0    221145
GASEOUS EMISSIONS                                                78.0    221145
                    FID        NDIR       NDIR       CHEMI      CHEMI    221145
                    UHC        CO         CO2        NO         NOX      221145
RANGE                2          2          2          1          1       221145
INSTR GAS TEMP      153.       57.        57.        64.        64.      221145
RAW VALUE MV         13.2      879.4      664.2      599.7      878.0    221145
GAS CONCEN PPM(C)   104.4      441.7      30678.3      14.6       21.4   221145
GAS CONCEN PCT      0.0104     0.0442     3.0678     0.0015     0.0021   221145
EMISSION INDEX       3.34       28.5      3109.         1.5        2.3   221145
FUEL-AIR RATIO      0.0152                                               221145
                                                                         221145
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COMBUSTOR RIG TEST                                                                  051135
DATE                         DATA POINT               TEST CELL                     051135
 1/25/77                     051135                   1                             051135
INSTRUMENT OPERATOR                                                                 051135
TREMBLEY                                              TEST OPERATOR                 051135
                                                      EHARDT                        051135
ENGINE MANUFACTURER          MODEL                    SERIAL NUMBER                 051135
LYCOMING                     ALF-502                  LFC4                          051135
FUEL IDENT.                  FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH        051135
JET-A HC RATIO 0.158          370.                    222.5                         051135
ORIFICE AIRFLOW LB/SEC       PT3 PSIA                 TT3 DEG.RANKINE               051135
  7.1                         35.1                    747.8                         051135
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                                   051135
 400.0                       0.0145                                                 051135
SIMULATED INLET PRESSURE PO PSIA                                                    051135
14.696                                                                              051135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                          051135
564.7                                                                               051135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 051135
 25.8                                                                               051135
FILTER AREA .365 SI                                                                 051135
CLEAN CK SMOKE NUMBER 0                                                             051135
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH             051135
         0.0                3.0          0.50     11.290             76.0           051135
         0.0                4.0          0.49     11.240             76.0           051135
         0.0                7.0          0.50     11.240             75.0           051135
         2.3               11.0          0.52     11.290             76.0           051135
GASEOUS EMISSIONS                                                                   051135
                    FID          NDIR         NDIR         CHEMI        CHEMI       051135
                    UHC          CO           CO2          NO           NOX         051135
RANGE               1            2            2            2            2           051135
INSTP GAS TEMP      152.         61.          61.          64.          65.         051135
RAW VALUE MV         55.8        648.6        647.3        223.3        336.4       051135
GAS CONCEN PPM(C)     76.4        423.7        25855.3         21.5         32.6    051135
GAS CONCEN PCT      0.0076       0.0424       2.5855       0.0022       0.0033      051135
EMISSION INDEX       2.52         28.1        3112.           2.3          3.5      051135
FUEL-AIR RATIO      0.0148                                                          051135
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COMBUSTOR RIG TEST                                                                091145
DATE                          DATA POINT          TEST CELL                        091145
 1/25/77                      091145              1                                091145
INSTRUMENT OPERATOR                               TEST OPERATOR                    091145
TREMBLEY                                          EHARDT                           091145
ENGINE MANUFACTURER           MODEL               SERIAL NUMBER                    091145
LYCOMING                      ALF-502             LF04                             091145
FUEL IDENT.                   FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH           091145
JET-A HC RATIO 0.158           271.               222.5                            091145
ORIFICE AIRFLOW LB/SEC        PT3 PSIA            TT3 DEG.RANKINE                  091145
  7.1                          35.1               747.0                            091145
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                                 091145
 400.0                        0.0145                                               091145
SIMULATED INLET PRESSURE PO PSIA                                                   091145
14.696                                                                             091145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                         091145
564.7                                                                              091145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                091145
 50.1                                                                              091145
FILTER AREA .385 SI                                                                091145
CLEAN CK SMOKE NUMBER 0                                                            091145
SMOKE NUMBER      VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              091145
        0.0             3.0          0.50     11.290             74.0              091145
        0.0             4.0          0.52     11.290             74.0              091145
        0.0             7.0          0.50     11.290             73.0              091145
        2.3            11.0          0.51     11.290             75.0              091145
GASEOUS EMISSIONS                                                                  091145
                                                                                   091145
                   FID        NDIR        NDIR        CHEMI       CHEMI            091145
                   UHC        CO          CO2         NO          NOX              091145
RANGE              1          2           2           2           2                091145
INSTR GAS TEMP     153.       57.         57.         64.         64.              091145
RAW VALUE MV       95.9       837.7       653.3       209.5       317.0            091145
GAS CONCEN PPM(C)  76.5       417.4       30174.8     20.2        30.7             091145
GAS CONCEN PCT     0.0076     0.0417      3.0175      0.0020      0.0031           091145
EMISSION INDEX     2.49       27.4        3113.       2.2         3.3              091145
FUEL-AIR RATIO     0.0149                                                          091145
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COMBUSTOR RIG TEST                                                                    121145
DATE                          DATA POINT              TEST CELL                      121145
 1/25/77                      121145                  1                               121145
INSTRUMENT OPERATOR                                   TEST OPERATOR                   121145
TREMBLEY                                              EHARDT                          121145
ENGINE MANUFACTURER           MODEL                   SERIAL NUMBER                   121145
LYCOMING                      ALF-502                 LF04                            121145
FUEL IDENT.                   FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH          121145
JET-A HC RATIO 0.158           370.                   223.3                           121145
ORIFICE AIRFLOW LB/SEC        PT3 PSIA                TT3 DEG.RANKINE                 121145
  6.9                          35.1                   747.7                           121145
SIMULATED THRUST LBS          FUEL-AIR RATIO MEAS.                                    121145
 400.0                        0.0148                                                  121145
SIMULATED INLET PRESSURE PO PSIA                                                      121145
14.696                                                                                121145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                            121145
564.7                                                                                 121145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                   121145
105.2                                                                                 121145
FILTER AREA .385 SI                                                                   121145
CLEAN CK SMOKE NUMBER 0                                                               121145
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH               121145
         0.0                3.0         0.50     11.270            75.0               121145
         0.0                4.0         0.49     11.250            75.0               121145
         0.0                7.0         0.50     11.290            76.0               121145
         2.3               11.0         0.50     11.250            75.0               121145
GASEOUS EMISSIONS                                                                     121145
                    FID         NDIR        NDIR        CHEMI       CHEMI             121145
                    UHC          CO          CO2         NO          NOX              121145
RANGE                1           2           2           2           2                121145
INSTR GAS TEMP      153.        56.         56.         64.         64.               121145
RAW VALUE MV        108.7       836.8       657.8       180.6       276.7             121145
GAS CONCEN PPM(C)    86.7       416.8      30414.7        17.4        26.8            121145
GAS CONCEN PCT      0.0087      0.0417      3.0415      0.0017      0.0027            121145
EMISSION INDEX       2.80        27.2       3113.          1.9         2.9            121145
FUEL-AIR RATIO      0.0151                                                            121145
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COMBUSTOR RIG TEST                                                                   141145
DATE                           DATA POINT               TEST CELL                    141145
 1/26/77                       141145                   1                            141145
INSTRUMENT OPERATOR                                     TEST OPERATOR                141145
TREMBLEY                                                EHARDT                       141145
ENGINE MANUFACTURER            MODEL                    SERIAL NUMBER                141145
LYCOMING                       ALF-502                  LFC4                         141145
FUEL IDENT.                    FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH       141145
JET-A HC RATIO 0.158            370.                    225.0                        141145
ORIFICE AIRFLOW LB/SEC         PT3 PSIA                 TT3 DEG.RANKINE              141145
  6.9                           35.0                    750.1                        141145
SIMULATED THRUST LBS           FUEL-AIR RATIO MEAS.                                  141145
 400.0                         0.0148                                                141145
SIMULATED INLET PRESSURE PO PSIA                                                     141145
14.696                                                                               141145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                           141145
564.7                                                                                141145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                  141145
172.1                                                                                141145
FILTER AREA .385 SI                                                                  141145
CLEAN CK SMOKE NUMBER 0                                                              141145
SMOKE NUMBER      VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH               141145
      0.0               3.0          0.50    11.330              74.0                141145
      0.0               4.0          0.50    11.280              74.0                141145
      2.3               7.0          0.50    11.310              74.0                141145
      2.3              11.0          0.50    11.280              75.0                141145
GASEOUS EMISSIONS                                                                    141145
                   FID        NDIR       NDIR        CHEMI      CHEMI                141145
                   UHC         CO         CO2         NO         NOX                 141145
RANGE               2          2          2           1          1                   141145
INSTR GAS TEMP     152.       56.        56.         64.        64.                  141145
RAW VALUE MV        16.3     541.4      651.3       576.2      855.1                 141145
GAS CONCEN PPM(C)  128.9     478.6    29651.3        14.2       22.1                 141145
GAS CONCEN PCT     0.0129    0.0479     2.9651      0.0014     0.0022                141145
EMISSION INDEX      4.26      31.9     3101.          1.6        2.4                 141145
FUEL-AIR RATIO     0.0147                                                            141145
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COMBUSTOR RIG TEST                                                                      171135
DATE                              DATA POINT             TEST CELL                      171135
 1/26/77                          171135                 1                              171135
INSTRUMENT OPERATOR                                      TEST OPERATOR                  171135
TREMBLEY                                                 EHARDT                         171135
ENGINE MANUFACTURER               MODEL                  SERIAL NUMBER                  171135
LYCOMING                          ALF-502                LF04                           171135
FUEL IDENT.                       FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH         171135
JET-A HC RATIO 0.158               399.                  226.2                          171135
ORIFICE AIRFLOW LB/SEC            PT3 PSIA               TT3 DEG.RANKINE                171135
  8.1                              38.0                  747.1                          171135
SIMULATED THRUST LBS              FUEL-AIR RATIO MEAS.                                  171135
 400.0                            0.0137                                                171135
SIMULATED INLET PRESSURE PO PSIA                                                        171135
15.855                                                                                  171135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                              171135
564.7                                                                                   171135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                     171135
 24.9                                                                                   171135
FILTER AREA .385 SI                                                                     171135
CLEAN CK SMOKE NUMBER 0                                                                 171135
SMOKE NUMBER         VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH               171135
        0.0                 3.0           0.50     11.270                73.0           171135
        2.3                 4.0           0.49     11.270                73.0           171135
        2.3                 7.0           0.50     11.270                73.0           171135
        2.3                11.0           0.50     11.270                74.0           171135
GASEOUS EMISSIONS                                                                       171135
                     FID         NDIR        NDIR         CHEMI       CHEMI             171135
                     UHC          CO          CO2          NO          NOX              171135
RANGE                 1           2           2            2           2                171135
INSTR GAS TEMP       153.        55.         55.          64.         64.               171135
RAW VALUE MV          85.4       827.5       633.5        201.3       323.7             171135
GAS CONCEN PPM(C)      67.4       408.2       28736.5        19.6        31.8           171135
GAS CONCEN PCT       0.0067      0.0408      2.8737       0.0020      0.0032            171135
EMISSION INDEX        2.31        28.1       3113.           2.2         3.6            171135
FUEL-AIR RATIO       0.0142                                                             171135
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COMBUSTOR RIG TEST                                                              181145
DATE                        DATA POINT               TEST CELL                  181145
 1/26/77                    181145                   1                          181145
INSTRUMENT OPERATCR                                  TEST CPERATCR              181145
TREMBLEY                                             EHARDT                     181145
ENGINE MANUFACTURER         MODEL                    SERIAL NUMBER              181145
LYCOMING                    ALF-5C2                  LFC4                       181145
FUEL IDENT.                 FUEL FLCW PPH            MANIFCLD FUEL TEMP FAH     181145
JET-A HC RATIO C.158         398.                    223.1                      181145
ORIFICE AIRFLOW LB/SEC      PT3 PSIA                 TT3 DEG.RANKINE            181145
  7.5                        38.C                    749.8                      181145
SIMULATED THRUST LBS        FUEL-AIR RATIC MEAS.                                181145
 400.0                      C.0147                                              181145
SIMULATED INLET PRESSURE PC PSIA                                                181145
15.855                                                                          181145
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                      181145
564.7                                                                           181145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             181145
170.6                                                                           181145
FILTER AREA .385 SI                                                             181145
CLEAN CK SMOKE NUMBER C                                                         181145
SMOKE NUMBER        VCL.-LITERS    FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH          181145
        0.0                 3.0        C.50    11.280               74.0        181145
        0.C                 4.C        C.50    11.260               74.C        181145
        0.0                 7.C        C.49    11.26C               74.0        181145
        2.3                11.0        C.50    11.26C               75.C        181145
GASEOUS EMISSICNS                                                               181145
                    FID       NDIR      NDIR      CHEMI     CHEMI               181145
                    UFC        CO       CC2       NO        NOX                 181145
RANGE                2          2         2        1         1                  181145
INSTR GAS TEMP      153.      57.       57.       64.       64.                 181145
RAW VALUE MV         14.9     893.6     646.0     563.3     899.1               181145
GAS CONCEN PPM(C)   117.9      446.6     29376.8      13.9      22.2            181145
GAS CONCEN PCT      C.C118    C.0447    2.9377    0.CC14    0.CC22              181145
EMISSION INDEX       3.94      30.0     3104.         1.5       2.5             181145
FUEL-AIR RATIC      C.C146                                                      181145
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COMBUSTOR RIG TEST                                                     042135
DATE                         DATA POINT           TEST CELL            042135
 1/26/77                     042135               1                    042135
INSTRUMENT OPERATOR                               TEST OPERATOR        042135
TREMBLEY                                          EHARDT               042135
ENGINE MANUFACTURER          MODEL                SERIAL NUMBER        042135
LYCOMING                     ALF-502              LF04                 042135
FUEL IDENT.                  FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH 042135
JET-A HC RATIO 0.158          432.                228.1                042135
ORIFICE AIRFLOW LB/SEC       PT3 PSIA             TT3 DEG.RANKINE      042135
 10.3                         40.1                784.0                042135
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                      042135
 600.0                       0.0116                                    042135
SIMULATED INLET PRESSURE PO PSIA                                       042135
14.696                                                                 042135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                             042135
544.7                                                                  042135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                    042135
 25.0                                                                  042135
FILTER AREA .385 SI                                                    042135
CLEAN CK SMOKE NUMBER 0                                                042135
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH 042135
          0.0              3.0          0.50    11.260           73.0  042135
          0.0              4.0          0.50    11.230           73.0  042135
          0.0              7.0          0.50    11.260           73.0  042135
          2.3             11.0          0.50    11.230           73.0  042135
GASEOUS EMISSIONS                                                      042135
                   FID        NDIR        NDIR        CHEMI     CHEMI     042135
                   UHC         CO          CO2         NO        NOX      042135
RANGE               2          2           2           1         1        042135
INSTR GAS TEMP     153.       55.         55.         64.       64.       042135
RAW VALUE MV        12.1      925.5       924.9       611.2     *****     042135
GAS CONCEN PPM(C)    95.4      467.3       23276.3      15.0      24.8    042135
GAS CONCEN PCT     0.0095     0.0467      2.3276      0.0015    0.0025    042135
EMISSION INDEX      4.00       39.5       3089.         2.1       3.4     042135
FUEL-AIR RATIO     0.0116                                                 042135
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COMBUSTOR RIG TEST
DATE                    DATA POINT        TEST CELL                  C82145
 1/26/77                C82145            1                          C82145
INSTRUMENT OPERATOR                       TEST OPERATOR              C82145
TREMBLEY                                  EFARDT                     C82145
ENGINE MANUFACTURER     MODEL             SERIAL NUMBER              C82145
LYCOMING                ALF-502           LF04                       C82145
FUEL IDENT.             FUEL FLOW PPH     MANIFOLD FUEL TEMP FAH     C82145
JET-A HC RATIO 0.158     432.             225.9                      C82145
ORIFICE AIRFLOW LB/SEC  PT3 PSIA          TT3 DEG.RANKINE            C82145
 10.3                    40.1             783.9                      C82145
SIMULATED THRUST LBS    FUEL-AIR RATIO MEAS.                         C82145
 600.0                  0.0117                                       C82145
SIMULATED INLET PRESSURE PO PSIA                                     C82145
14.696                                                               C82145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                           C82145
544.7                                                                C82145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                  C82145
 49.3                                                                C82145
FILTER AREA .385 SI                                                  C82145
CLEAN CK SMOKE NUMBER 0                                              C82145
SMOKE NUMBER      VOL.-LITERS    FLOW-CFM  PRESS.-PSIA  TEMP. DEG.FAH C82145
        0.0              3.0        0.50       11.230          73.0  C82145
        0.0              4.0        0.50       11.300          73.0  C82145
        2.3              7.0        0.50       11.300          73.0  C82145
        2.3             11.0        0.50       11.280          73.0  C82145
GASEOUS EMISSIONS                                                    C82145
                  FID        NDIR        NDIR      CHEMI     CHEMI   C82145
                  UHC        CO          CO2       NO        NOX     C82145
RANGE              2          2           2         1         1      C82145
INSTR GAS TEMP    153.       55.         55.       64.       64.     C82145
RAW VALUE MV       13.4      536.6       525.8     574.3     539.0   C82145
GAS CONCEN PPM(C)  105.7      475.4    23319.7      14.1      23.0   C82145
GAS CONCEN PCT    0.0106     0.0475      2.3320    0.0014    0.0023  C82145
EMISSION INDEX     4.47       40.1      3087.       1.5       3.2    C82145
FUEL-AIR RATIO    0.0116                                             C82145
                                                                     C82145
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COMBUSTOR RIG TEST                                                          112145
DATE                        DATA POINT         TEST CELL                    112145
 1/26/77                    112145             1                            112145
INSTRUMENT OPERATOR                            TEST OPERATOR                112145
TREMBLEY                                       EHARDT                       112145
ENGINE MANUFACTURER         MODEL              SERIAL NUMBER                112145
LYCOMING                    ALF-502            LF04                         112145
FUEL IDENT.                 FUEL FLOW PPH      MANIFOLD FUEL TEMP FAH       112145
JET-A HC RATIO 0.158         432.              222.5                        112145
ORIFICE AIRFLOW LB/SEC      PT3 PSIA           TT3 DEG.RANKINE              112145
 10.1                        40.1              782.1                        112145
SIMULATED THRUST LBS        FUEL-AIR RATIO MEAS.                            112145
 600.0                      0.0119                                          112145
SIMULATED INLET PRESSURE PO PSIA                                            112145
14.696                                                                      112145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                  112145
544.7                                                                       112145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         112145
101.7                                                                       112145
FILTER AREA .385 SI                                                         112145
CLEAN CK SMOKE NUMBER 0                                                     112145
SMOKE NUMBER     VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH        112145
         0.0             3.0         0.50    11.280              72.0       112145
         0.0             4.0         0.50    11.300              72.0       112145
         0.0             7.0         0.50    11.250              72.0       112145
         2.3            11.0         0.50    11.250              72.0       112145
GASEOUS EMISSIONS                                                           112145
                 FID         NDIR        NDIR       CHEMI      CHEMI        112145
                 UHC          CO          CO2        NO         NOX         112145
RANGE             2            2           2         1          1           112145
INSTR GAS TEMP   153.         53.         53.       64.        64.          112145
RAW VALUE MV      15.9       947.2       530.5     513.8      829.9         112145
GAS CONCEN PPM(C) 126.0       483.8     23556.7       12.6       20.3       112145
GAS CONCEN PCT   0.0126      0.0484      2.3557    0.0013     0.0020        112145
EMISSION INDEX    5.22        40.3       3084.        1.7        2.8        112145
FUEL-AIR RATIO   0.0117                                                     112145
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COMBUSTOR RIG TEST                                                          132145
DATE                         DATA POINT            TEST CELL                132145
 1/26/77                     132145                1                        132145
INSTRUMENT OPERATOR                                TEST OPERATOR            132145
TREMBLEY                                           EFARDT                   132145
ENGINE MANUFACTURER          MODEL                 SERIAL NUMBER            132145
LYCOMING                     ALF-502               LF04                     132145
FUEL IDENT.                  FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH   132145
JET-A HC RATIO 0.158          432.                 224.7                    132145
ORIFICE AIRFLOW LB/SEC       PT3 PSIA              TT3 DEG.RANKINE          132145
  9.6                         40.2                 783.0                    132145
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                           132145
 600.0                        0.0125                                        132145
SIMULATED INLET PRESSURE PO PSIA                                            132145
14.696                                                                      132145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                  132145
544.7                                                                       132145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         132145
171.8                                                                       132145
FILTER AREA .385 SI                                                         132145
CLEAN CK SMOKE NUMBER 0                                                     132145
SMOKE NUMBER       VOL.-LITERS    FLOW-CFM  PRESS.-PSIA  TEMP. DEG.FAH      132145
      0.0               3.0         0.52     11.330             72.0        132145
      0.0               4.0         0.50     11.260             72.0        132145
      0.0               7.0         0.50     11.260             72.0        132145
      2.3              11.0         0.50     11.260             72.0        132145
GASEOUS EMISSIONS                                                           132145
                   FID        NDIR      NDIR       CHEMI     CHEMI          132145
                   UHC         CO        CO2        NO        NOX           132145
RANGE               2          3          2          1         1            132145
INSTR GAS TEMP     153.       53.        53.        64.       64.           132145
RAW VALUE MV       20.6      419.5      536.4      448.6     722.6          132145
GAS CONCEN PPM(C)   163.7     523.7     23852.3       11.0      17.7        132145
GAS CONCEN PCT     0.0164    0.0524     2.3852     0.0011    0.0018         132145
EMISSION INDEX      6.67      43.0      3075.         1.5       2.4         132145
FUEL-AIR RATIO     0.0119                                                   132145
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COMBUSTOR RIG TEST
DATE
 1/26/77                          DATA POINT
INSTRUMENT OPERATOR               212135              TEST CELL                 212135
TREMBLEY                                              1                         212135
ENGINE MANUFACTURER                                   TEST OPERATOR             212135
LYCOMING                          MODEL               EHARDT                    212135
FUEL IDENT.                       ALF-502             SERIAL NUMBER             212135
JET-A HC RATIO 0.158              FUEL FLOW PPH       LF04                      212135
ORIFICE AIRFLOW LB/SEC             385.               MANIFOLD FUEL TEMP FAH    212135
  8.5                             PT3 PSIA            227.9                     212135
SIMULATED THRUST LBS               34.8               TT3 DEG.RANKINE           212135
 600.0                            FUEL-AIR RATIO MEAS. 811.3                    212135
SIMULATED INLET PRESSURE PO PSIA  0.0125                                        212135
12.761                                                                          212135
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                      212135
564.7                                                                           212135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             212135
 25.2                                                                           212135
FILTER AREA .385 SI                                                             212135
CLEAN CK SMOKE NUMBER 0                                                         212135
SMOKE NUMBER                                                                    212135
         0.0      VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH           212135
         0.0          3.0          0.50     11.270              74.0            212135
         0.0          4.0          0.49     11.240              74.0            212135
         2.3          7.0          0.50     11.270              74.0            212135
GASEOUS EMISSIONS    11.0          0.50     11.240              74.0            212135
             FID                                                                212135
RANGE        UHC        NDIR       NDIR       CHEMI                             212135
INSTR GAS TEMP  1       CO         CO2        NO         CHEMI                  212135
RAW VALUE MV  153.       2          2          2         NOX                    212135
GAS CONCEN PPM(C) 77.4  63.        63.        64.         2                     212135
GAS CONCEN PCT   61.4   855.0      570.7      192.0      64.                    212135
EMISSION INDEX  0.0061  447.2      25630.5     18.8      294.7                  212135
FUEL-AIR RATIO   2.35   0.0447     2.5631     0.0019      28.9                  212135
                0.0127  34.5       3103.        2.4      0.0029                 212135
                                                           3.7                  212135
                                                                                212135
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COMBUSTOR RIG TEST                                                                    222145
DATE                             DATA POINT               TEST CELL                   222145
 1/26/77                         222145                   1                           222145
INSTRUMENT OPERATOR                                       TEST OPERATOR               222145
TREMBLEY                                                  EFAFCT                      222145
ENGINE MANUFACTURER              MODEL                    SERIAL NUMBER               222145
LYCOMING                         ALF-502                  LFC4                        222145
FUEL IDENT.                      FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH      222145
JET-A HC RATIO 0.158              385.                    226.9                       222145
ORIFICE AIRFLOW LB/SEC           PT3 PSIA                 TT3 DEG.RANKINE             222145
  8.1                             34.8                    810.3                       222145
SIMULATED THRUST LBS             FUEL-AIR RATIO MEAS.                                 222145
 600.0                           0.0131                                               222145
SIMULATED INLET PRESSURE P0 PSIA                                                      222145
12.761                                                                                222145
SIMULATED INLET TEMPERATURE T0 DEG.RANKINE                                            222145
564.7                                                                                 222145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                   222145
173.4                                                                                 222145
FILTER AREA .385 SI                                                                   222145
CLEAN CK SMOKE NUMBER 0                                                               222145
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM PRESS.-PSIA   TEMP. DEG.FAH               222145
      0.0                  3.0         0.50     11.260             73.0               222145
      0.0                  4.0         0.50     11.230             73.0               222145
      0.0                  7.0         0.50     11.260             73.0               222145
      2.3                 11.0         0.50     11.230             73.0               222145
GASEOUS EMISSIONS                                                                     222145
                 FID        NDIR        NDIR       CHEMI      CHEMI                   222145
                 UHC        CO          CO2        NO         NOX                     222145
RANGE             2          2           2          1          1                      222145
INSTR GAS TEMP   153.       57.         57.        64.        64.                     222145
RAW VALUE MV      15.8      562.7       577.4      517.6      792.3                   222145
GAS CONCEN PPM(C) 126.1      496.1       25972.1      12.9       19.6                 222145
GAS CONCEN PCT   0.0126     0.0496      2.5972     0.0013     0.0020                  222145
EMISSION INDEX    4.74       37.6       3090.         1.6        2.4                  222145
FUEL-AIR RATIO   0.0129                                                               222145
                                                                                      222145
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COMBUSTOR RIG TEST
DATE                          DATA POINT            TEST CELL                  052135
 1/26/77                      052135                1                          052135
INSTRUMENT OPERATOR                                                            052135
TREMBLEY                                            TEST OPERATOR              052135
ENGINE MANUFACTURER                                 EFARDT                     052135
LYCOMING                      MODEL                 SERIAL NUMBER              052135
FUEL IDENT.                   ALF-502               LFC4                       052135
JET-A HC RATIO 0.158          FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH     052135
ORIFICE AIRFLOW LB/SEC         443.                 223.7                      052135
 10.1                         PT3 PSIA              TT3 DEG.RANKINE            052135
SIMULATED THRUST LBS           40.1                 810.8                      052135
 600.0                        FUEL-AIR RATIO MEAS.                             052135
                              0.0121                                           052135
SIMULATED INLET PRESSURE PC PSIA                                               052135
14.696                                                                         052135
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                     052135
564.7                                                                          052135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                            052135
 25.1                                                                          052135
FILTER AREA .385 SI                                                            052135
CLEAN CK SMOKE NUMBER 0                                                        052135
SMOKE NUMBER       VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH        052135
        0.0               3.0          0.50      11.300              72.0      052135
        0.0               4.0          0.50      11.300              72.0      052135
        0.0               7.0          0.50      11.300              73.0      052135
        2.3              11.0          0.50      11.250              72.0      052135
GASEOUS EMISSIONS                                                              052135
                   FID        NDIR       NDIR       CHEMI      CHEMI           052135
                   UHC        CO         CO2        NO         NOX             052135
RANGE               1          2          2          2          2              052135
INSTR GAS TEMP     153.       57.        57.        64.        64.             052135
RAW VALUE MV        90.2      878.6      546.2      190.3      284.9           052135
GAS CONCEN PPM(C)    71.6      437.8      24386.7       18.5       27.8        052135
GAS CONCEN PCT     0.0072     0.0438     2.4387     0.0019     0.0028          052135
EMISSION INDEX      2.88       35.4      3059.          2.5        3.7         052135
FUEL-AIR RATIO     0.0121                                                      052135
                                                                               052135
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COMBUSTOR RIG TEST                                                          092145
DATE                     DATA POINT              TEST CELL                  092145
 1/26/77                 092145                  1                          092145
INSTRUMENT OPERATOR                              TEST OPERATOR              092145
TREMBLEY                                         EHARDT                     092145
ENGINE MANUFACTURER      MODEL                   SERIAL NUMBER              092145
LYCOMING                 ALF-502                 LF04                       092145
FUEL IDENT.              FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH     092145
JET-A HC RATIO 0.158      442.                   223.1                      092145
ORIFICE AIRFLOW LB/SEC   PT3 PSIA                TT3 DEG.RANKINE            092145
 10.0                     40.1                   810.4                      092145
SIMULATED THRUST LBS     FUEL-AIR RATIO MEAS.                               092145
 600.0                   0.0122                                             092145
SIMULATED INLET PRESSURE PO PSIA                                            092145
14.696                                                                      092145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                  092145
564.7                                                                       092145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         092145
 49.5                                                                       092145
FILTER AREA .385 SI                                                         092145
CLEAN CK SMOKE NUMBER 0                                                     092145
SMOKE NUMBER      VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       092145
        0.0              3.0          0.50   11.310             72.0        092145
        0.0              4.0          0.49   11.230             72.0        092145
        0.0              7.0          0.50   11.260             72.0        092145
        2.3             11.0          0.50   11.260             72.0        092145
GASEOUS EMISSIONS                                                           092145
                  FID        NDIR       NDIR        CHEMI      CHEMI        092145
                  UHC         CO         CO2         NO         NOX         092145
RANGE              1          2          2          2          2            092145
INSTR GAS TEMP    153.       57.        57.        64.        64.           092145
RAW VALUE MV      103.3      887.5      547.0      172.9      264.7         092145
GAS CONCEN PPM(C)   82.1      443.1      24426.1       16.8       25.9      092145
GAS CONCEN PCT    0.0082     0.0443     2.4426     0.0017     0.0026        092145
EMISSION INDEX     3.29       35.8      3057.         2.2        3.4        092145
FUEL-AIR RATIO    0.0121                                                    092145
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COMBUSTOR RIG TEST
DATE                                                                         122145
 1/26/77                         DATA POINT           TEST CELL              122145
INSTRUMENT OPERATOR              122145               1                      122145
TREMBLEY                                              TEST OPERATOR          122145
ENGINE MANUFACTURER                                   EHARDT                 122145
LYCOMING                         MODEL                SERIAL NUMBER          122145
FUEL IDENT.                      ALF-502              LF04                   122145
JET-A HC RATIO C.1K,             FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH 122145
ORIFICE AIRFLOW LB/SEC            442.                224.1                  122145
  9.9                            PT3 PSIA             TT3 DEG.RANKINE        122145
SIMULATED THRUST LBS              40.1                810.6                  122145
 600.0                           FUEL-AIR RATIO MEAS.                        122145
                                 0.0124                                      122145
SIMULATED INLET PRESSURE PO PSIA                                             122145
14.696                                                                       122145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                   122145
564.7                                                                        122145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                          122145
103.1                                                                        122145
FILTER AREA .385 SI                                                          122145
CLEAN CK SMOKE NUMBER 0                                                      122145
SMOKE NUMBER      VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH        122145
       0.0               3.0          0.50    11.260             72.0        122145
       0.0               4.0          0.50    11.260             72.0        122145
       0.0               7.0          0.52    11.260             72.0        122145
       2.3              11.0          0.51    11.280             73.0        122145
GASEOUS EMISSIONS                                                            122145
                  FID        NDIR       NDIR       CHEMI      CHEMI          122145
                  UHC        CO         CO2        NO         NOX            122145
RANGE              2          2          2          1          1             122145
INSTR GAS TEMP    153.       55.        55.        64.        64.            122145
RAW VALUE MV       12.4      504.9      549.0      594.3      921.5          122145
GAS CONCEN PPM(C)   57.8      453.8     24531.0       14.7       22.7        122145
GAS CONCEN PCT    0.0058     0.0454     2.4531     0.0015     0.0023         122145
EMISSION INDEX     2.50       36.4      3055.         1.5        3.0         122145
FUEL-AIR RATIO    0.0122                                                     122145
                                                                             122145
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COMBUSTION RIG TEST                                                                          142145
DATE                               DATA POINT              TEST CELL                         142145
 1/26/77                           142145                  1                                 142145
INSTRUMENT OPERATOR                                        TEST OPERATOR                     142145
TREMPLEY                                                   EHARDT                            142145
ENGINE MANUFACTURER                MODEL                   SERIAL NUMBER                     142145
LYCOMING                           ALF-502                 LF04                              142145
FUEL IDENT.                        FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH            142145
JET-A HC RATIO 0.150                442.                   223.6                             142145
ORIFICE AIRFLOW LB/SEC             PT3 PSIA                TT3 DEG.RANKINE                   142145
  9.6                               40.1                   811.0                             142145
SIMULATED THRUST LBS               FUEL-AIR RATIO MEAS.                                      142145
 600.0                             0.0128                                                    142145
SIMULATED INLET PRESSURE PO PSIA                                                             142145
14.696                                                                                       142145
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                                   142145
564.7                                                                                        142145
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                          142145
100.0                                                                                        142145
FILTER AREA .385 SI                                                                          142145
CLEAN CK SMOKE NUMBER 0                                                                      142145
SMOKE NUMBER            VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH                 142145
        0.0                     3.0          0.50      11.260             72.0               142145
        0.0                     4.6          0.49      11.240             72.0               142145
        0.0                     7.0          0.50      11.240             73.0               142145
        2.3                    11.0          0.50      11.260             73.0               142145
GASEOUS EMISSIONS                                                                            142145
                        FID        NDIR        NDIR         CHEMI      CHEMI                 142145
                        UHC         CO          CO2          NO         NOX                  142145
RANGE                    2          2            2            1          1                   142145
INSTR GAS TEMP          153.       54.          54.          64.        64.                  142145
RAW VALUE MV             15.7      435.9        550.7        521.3      796.0                142145
GAS CONCEN PPM(C)        174.9      474.9      24617.4        12.9        15.7               142145
GAS CONCEN PCT          0.0125     0.0475       2.4617       0.0013     0.0020               142145
EMISSION INDEX           4.96       37.93      3089.          1.7        2.6                 142145
FUEL-AIR RATIO          0.0123                                                               142145
                                                                                             142145
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COMBUSTION RIG TEST
DATE                                                              172135
 3/29/77                  CATA FCINT           TEST CELL          172135
INSTRUMENT OPERATCR       172135               1                  172135
TREMBLEY                                       TEST CPERATCR      172135
ENGINE MANUFACTURER                            EHARCT             172135
LYCOMING                  MCDEL                SERIAL NUMBER      172135
FUEL IDENT.               ALF-502              LF04               172135
JET-A HC RATIO C.192      FUEL FLCW PPH        MANIFCLD FUEL TEMP FAH 172135
ORIFICE AIRFLCW LB/SEC     478.                226.4              172135
 10.9                     PT3 PSIA             TT3 DEG.RANKINE    172135
SIMULATED THRUST LBS       43.4                811.5              172135
 600.0                    FUEL-AIR RATIC MEAS.                    172135
                          C.0122                                  172135
SIMULATED INLET PRESSURE PC PSIA                                  172135
19.055                                                            172135
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                        172135
546.7                                                             172135
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                               172135
 26.7                                                             172135
FILTER AREA .385 SI                                               172135
CLEAN CK SMOKE NUMBER C                                           172135
SMOKE NUMBER         VCL.-LITERS    FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH  172135
       0.0                  3.0         C.51    11.240            78.0   172135
       4.4                  4.C         C.52    11.461            78.0   172135
       7.3                  7.C         C.51    11.240            78.C   172135
       7.3                 11.C         C.51    11.240            77.C   172135
GASEOUS EMISSIONS                                                        172135
                 FIC        NDIR        NDIR       CHEMI      CHEMI      172135
                 UHC         CO          CC2        NC         NCX       172135
RANGE             1          2           2          1          2         172135
INSTR GAS TEMP   150.        61.         61.        65.        65.       172135
RAW VALUE MV      34.4      751.1       556.9      677.7      287.6      172135
GAS CONCEN PPM(C)   57.2     395.6      24199.C        16.6       28.9   172135
GAS CONCEN PCT   0.CC57     C.0396      2.4199     0.CC17     0.CC29     172135
EMISSION INDEX    2.37       32.5       3122.         2.2        3.5     172135
FUEL-AIR RATIO   C.C119                                                  172135
                                                                         172135
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COMBUSTOR RIG TEST                                                          182155
DATE                     CATA POINT         TEST CELL                       182155
 3/29/77                 182155             1                               182155
INSTRUMENT OPERATOR                         TEST OPERATOR                   182155
TREMBLEY                                    EHARDT                          182155
ENGINE MANUFACTURER      MODEL              SERIAL NUMBER                   182155
LYCOMING                 ALF-5C2            LF04                            182155
FUEL IDENT.              FUEL FLCW PPH      MANIFCLD FUEL TEMP FAH          182155
JET-A HC RATIO C.152      478.              224.7                           182155
ORIFICE AIRFLOW LB/SEC   PT3 PSIA           TT3 DEG.RANKINE                 182155
 10.4                     43.3              812.5                           182155
SIMULATED THRUST LBS     FUEL-AIR RATIC MEAS.                               182155
 690.0                   0.0127                                             182155
SIMULATED INLET PRESSURE PC PSIA                                            182155
19.055                                                                      182155
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                  182155
984.7                                                                       182155
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         182155
176.7                                                                       182155
FILTER AREA .785 SI                                                         182155
CLEAN CK SMOKE NUMBER 0                                                     182155
SMOKE NUMBER        VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH    182155
        2.3                 3.0          C.49    11.188             82.C    182155
        2.3                 4.C          C.50    11.237             82.0    182155
        2.3                 7.C          C.50    11.213             81.0    182155
        2.3                11.C          C.52    11.188             82.C    182155
GASEOUS EMISSIONS                                                           182155
                    FIC         NDIR       NCIR        CHEMI      CHEMI     182155
                    UHC          CO         CC2         NC         NCX      182155
RANGE                2           2           2           1          1       182155
INSTR GAS TEMP      190.        61.         61.         64.        64.      182155
RAW VALUE MV        18.5        531.C       564.3       477.3      789.1    182155
GAS CONCEN PPM(C)   146.0        483.8       24562.8       12.2       20.0  182155
GAS CONCEN PCT      C.C146      C.0484      2.4563      0.0C12     0.0020   182155
EMISSION INDEX      5.8C        38.5        3101.          1.6        2.6   182155
FUEL-AIR RATIC      C.C122                                                  182155
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COMBUSTION RIG TEST                                                           198144
DATE                     CATA PCINT          TEST CELL                        198144
 3/ 2/77                 159144              1                                198144
INSTRUMENT OPERATOR                          TEST CPERATOR                    198144
TRANSLEY                                     EHARDT                           198144
ENGINE MANUFACTURER      MODEL               SERIAL NUMBER                    198144
LYCOMING                 ALF-502             LF04                             198144
FUEL IDENT.              FUEL FLCW PPH       MANIFCLD FUEL TEMP FAH           198144
JET-A HC RATIO C.198     1198.               226.2                            198144
ORIFICE AIRFLOW LB/SEC   PT3 PSIA            TT3 DEG.RANKINE                  198144
 19.9                     80.3               852.7                            198144
SIMULATED THRUST LBS     FUEL-AIR RATIC MEAS.                                 198144
6900.0                   C.C182                                               198144
SIMULATED INLET PRESSURE PC PSIA                                              198144
12.761                                                                        198144
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                    198144
499.7                                                                         198144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           198144
 23.6                                                                         198144
FILTER AREA .385 SI                                                           198144
CLEAN CK SMOKE NUMBER C                                                       198144
SMOKE NUMBER        VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH       198144
        8.8                3.C          C.50      11.716             70.C     198144
       10.9                4.C          C.5C      11.692             7C.0     198144
       18.7                7.C          0.50      11.716             70.0     198144
       22.4               11.C          C.50      11.716             72.0     198144
GASEOUS EMISSICNS                                                             198144
                    FIC          NDIR         NDIR         CHEMI       CHEMI  198144
                    UHC          CC           CO2          NO          NOX    198144
RANGE                1            2            2           2           2      198144
INSTP GAS TEMP      154.         52.          52.          64.         64.    198144
RAW VALUE MV          5.5       354.7        807.2        413.9       519.2   198144
GAS CONCEN PPM(C)      4.8        147.2        37580.2        41.7       52.5 198144
GAS CONCEN PCT      C.CCC5      C.0147       3.7580       C.CC42      C.CC52  198144
EMISSION INDEX        C.13          7.9        3151.          3.7         4.6 198144
FUEL-AIR RATIO      C.C184                                                    198144
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COMBUSTOR RIG TEST
DATE                            DATA POINT             TEST CELL               193134
 3/ 2/77                        193134                 1                       193134
INSTRUMENT OPERATOR                                                            193134
TREMBLEY                                               TEST OPERATOR           193134
ENGINE MANUFACTURER                                    EFARCT                  193134
LYCOMING                        MODEL                  SERIAL NUMBER           193134
FUEL IDENT.                     ALF-502                LF04                    193134
JET-A HC RATIO 0.158            FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH  193134
ORIFICE AIRFLOW LB/SEC           659.                  225.3                   193134
 16.2                           FT3 PSIA               TT3 DEG.RANKINE         193134
SIMULATED THRUST LBS             65.4                  835.1                   193134
1950.0                          FUEL-AIR RATIO MEAS.                           193134
SIMULATED INLET PRESSURE PO PSIA                                               193134
12.761                          0.0113                                         193134
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                     193134
479.7                                                                          193134
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                            193134
 24.0                                                                          193134
FILTER AREA .385 SI                                                            193134
CLEAN CK SMOKE NUMBER 0                                                        193134
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH      193134
       2.3                    3.0          0.50     11.666             74.0    193134
       4.5                    4.0          0.52     11.666             74.0    193134
      10.9                    7.0          0.51     11.691             74.0    193134
      16.9                   11.0          0.51     11.715             74.0    193134
 GASEOUS EMISSIONS                                                             193134
                      FID        NDIR        NDIR       CHEMI     CHEMI        193134
RANGE                 UHC         CO          CO2        NO        NOX         193134
INSTR GAS TEMP         1          2            2          2         2          193134
RAW VALUE MV         154.        55.          55.        64.       64.         193134
GAS CONCEN PPM(C)     41.4       595.6       516.6      207.7     317.8        193134
GAS CONCEN PCT         35.4       264.5      22668.1      20.4      31.4       193134
EMISSION INDEX       0.0035      0.0265      2.2668     0.0020    0.0031       193134
FUEL-AIR RATIO        1.54       23.2        3123.        2.9       4.5        193134
                     0.0112                                                    193134
                                                                               193134
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COMBUSTOR RIG TEST                                                          C13144
DATE                        CATA POINT          TEST CELL                   C13144
 3/29/77                    C13144              1                           C13144
INSTRUMENT OPERATOR                             TEST OPERATOR               013144
TREMBLEY                                        EHARDT                      C13144
ENGINE MANUFACTURER         MODEL               SERIAL NUMBER               013144
LYCOMING                    ALF-502             LF04                        C13144
FUEL IDENT.                 FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH      C13144
JET-A HC RATIO C.192         738.               224.1                       013144
ORIFICE AIRFLOW LB/SEC      PT3 PSIA            TT3 DEG.RANKINE             013144
 18.6                        75.C               832.7                       013144
SIMULATED THRUST LBS        FUEL-AIR RATIO MEAS.                            C13144
1950.0                      0.011C                                          013144
SIMULATED INLET PRESSURE PC PSIA                                            013144
14.696                                                                      013144
SIMULATED INLET TEMPERATURE TC DEC.RANKINE                                  C13144
478.7                                                                       013144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         C13144
 26.5                                                                       C13144
FILTER AREA .385 SI                                                         013144
CLEAN CK SMOKE NUMBER 0                                                     C13144
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   C13144
        4.5                  2.0         C.48     11.341             79.0   013144
        4.5                  4.C         C.48     11.341             79.C   C13144
       10.9                  7.C         0.50     11.292             79.C   C13144
       14.9                 11.C         C.48     11.243             79.0   013144
GASEOUS EMISSIONS                                                           C13144
                      FID        NDIR       NDIR       CHEMI      CHEMI     C13144
                      UHC         CO         CO2        NO         NOX      C13144
RANGE                  1          2          2          1          2        C13144
INSTR GAS TEMP        15C.       59.        59.        65.        64.       C13144
RAW VALUE MV           42.2      520.3      513.4      81C.C      317.3     C13144
GAS CONCEN PPM(C)       33.6      230.3      22C69.5      2C.5       32.6   C13144
GAS CONCEN PCT        C.CC34     C.C23C     2.2070     C.CC2C     0.CC33    C13144
EMISSION INDEX         1.50       20.5      3143.        3.0        4.5     C13144
FUEL-AIR RATIO        C.C1C8                                                C13144
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COMBUSTOR RIG TEST                                                           153144
DATE                     CATA POINT          TEST CELL                       153144
 3/29/77                 153144              1                               153144
INSTRUMENT OPERATOR                          TEST OPERATOR                   153144
[illegible]                                  EHARDT                          153144
ENGINE MANUFACTURER      MODEL               SERIAL NUMBER                   153144
LYCOMING                 ALF-502             LF04                            153144
FUEL IDENT.              FUEL FLCW PPH       MANIFCLD FUEL TEMP FAH          153144
JET-A HC RATIO C.192      807.               225.3                           153144
ORIFICE AIRFLOW LB/SEC   PT3 PSIA            TT3 DEG.RANKINE                 153144
 29.7                     81.1               834.2                           153144
SIMULATED THRUST LBS     FUEL-AIR RATIC MEAS.                                153144
1950.0                   C.0111                                              153144
SIMULATED INLET PRESSURE PO PSIA                                             153144
15.055                                                                       153144
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                   153144
678.7                                                                        153144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                          153144
 26.6                                                                        153144
FILTER AREA .385 SI                                                          153144
CLEAN CK SMOKE NUMBER 0                                                      153144
SMOKE NUMBER        VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH      153144
        7.3                 3.0         C.50    11.340              74.0     153144
       10.9                 4.C         C.50    11.34C              74.0     153144
       14.9                 7.C         C.50    11.340              74.0     153144
       16.8                11.C         C.51    11.340              74.0     153144
GASEOUS EMISSICNS                                                            153144
                    FID        NDIR        NCIR        CHEMI     CHEMI       153144
                    UHC         CO          CC2         NC        NCX        153144
RANGE                1          2           2          2         2           153144
INSTR GAS TEMP      150.       59.         59.         64.       64.         153144
RAW VALUE MV         35.8      5C6.1       518.7      226.8     326.3        153144
GAS CONCEN PPM(C)     30.2      221.3       2232C.8        22.9      33.2    153144
GAS CONCEN PCT      C.CO3C    C.0221      2.2321      C.CC23    0.CC33       153144
EMISSION INDEX       1.34      19.8       3145.          3.4       4.9       153144
FUEL-AIR RATIO      C.C109                                                   153144
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COMBUSTOR RIG TEST
DATE                                                                          023134
  3/25/77                           DATA POINT            TEST CELL           023134
                                    023134                1                   023134
INSTRUMENT OPERATOR                                                            023134
TREMPLEY                                                  TEST OPERATOR       023134
                                                          EHARDT              023134
ENGINE MANUFACTURER                 MODEL                 SERIAL NUMBER       023134
LYCOMING                            ALF-502               LF04                023134
FUEL IDENT.                         FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH 023134
JET-A HC RATIO 0.152                 758.                 226.8               023134
ORIFICE AIRFLOW LB/SEC              PT3 PSIA              TT3 DEG.RANKINE     023134
 18.3                                75.0                 666.0               023134
SIMULATED THRUST LBS                FUEL-AIR RATIO MEAS.                      023134
1950.0                              0.0115                                    023134
SIMULATED INLET PRESSURE PO PSIA                                              023134
14.696                                                                        023134
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                    023134
498.7                                                                         023134
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           023134
 25.1                                                                         023134
FILTER AREA .385 SI                                                           023134
CLEAN CK SMOKE NUMBER 0                                                       023134
SMOKE NUMBER            VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH  023134
         2.3                    3.0          0.50     11.335            80.0  023134
         6.7                    4.0          0.50     11.335            80.0  023134
         6.7                    7.0          0.50     11.335            80.0  023134
        12.9                   11.0          0.48     11.286            80.0  023134
GASEOUS EMISSIONS                                                             023134
                    FID         NDIR        NDIR       CHEMI      CHEMI       023134
                    UHC          CO          CO2        NO         NOX        023134
RANGE                1           2           2          2          2          023134
INSTR GAS TEMP      150.        61.         61.        65.        64.         023134
RAW VALUE MV         28.8       503.5       539.9      247.3      358.4       023134
GAS CONCEN PPM(C)     28.8       221.2       23300.6       25.4       36.8    023134
GAS CONCEN PCT      0.0029      0.0221      2.3301     0.0025     0.0037      023134
EMISSION INDEX       1.22        19.0        3147.         3.6        5.2     023134
FUEL-AIR RATIO      0.0114                                                    023134
                                                                              023134
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COMBUSTOR RIG TEST                                                                    C63144
DATE                            CATA FOINT           TEST CELL                        C63144
 3/25/77                        C63144               1                                063144
INSTRUMENT OPERATOR                                  TEST OPERATOR                    C63144
TREMBLEY                                             EHARDT                           063144
ENGINE MANUFACTURER             MODEL                SERIAL NUMBER                    C63144
LYCOMING                        ALF-5C2              LFC4                             C63144
FUEL IDENT.                     FUEL FLCW PPH        MANIFOLC FUEL TEMP FAH           063144
JET-A HC RATIO C.192             767.                226.8                            063144
ORIFICE AIRFLOW LB/SEC          FT3 PSIA             TT3 CEG.RANKINE                  C63144
 18.3                            75.C                867.2                            063144
SIMULATED THRUST LBS            FUEL-AIR RATIC MEAS.                                  063144
1950.0                          C.0116                                                C63144
SIMULATED INLET PRESSURE PO PSIA                                                      C63144
14.696                                                                                063144
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                            063144
499.7                                                                                 C63144
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                   C63144
 35.4                                                                                 063144
FILTER AREA .385 SI                                                                   C63144
CLEAN CK SMOKE NUMBER C                                                               C63144
SMOKE NUMBER           VCL.-LITERS      FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH           C63144
        4.6                    3.0          C.50      11.385           78.C           C63144
        6.7                    4.C          C.50      11.336           78.C           C63144
        8.8                    7.0          C.50      11.336           78.0           063144
       12.9                   11.C          0.48      11.287           79.C           C63144
 GASEOUS EMISSIONS                                                                    C63144
                       FIC         NDIR        NDIR        CHEMI        CHEMI         C63144
                       UHC          CO          CO2         NO           NOX          063144
RANGE                   1           2           2           2            2            063144
INSTR GAS TEMP         15C.        59.         55.         64.          64.           C63144
RAW VALUE MV           31.9       510.5       537.8       239.5        346.7          C63144
GAS CONCEN PPM(C)       32.1       225.1      23198.C        24.6         35.6        C63144
GAS CONCEN PCT        C.CC32      C.C225      2.3158      C.CC25       C.CC36         C63144
EMISSION INDEX         1.37        19.4       3146.          3.5          5.C         C63144
FUEL-AIR RATIO        C.C113                                                          C63144
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COMBUSTOR RIG TEST                                                       203144
DATE                       DATA POINT          TEST CELL                 203144
 3/25/77                   2C3144              1                         203144
INSTRUMENT OPERATOR                            TEST OPERATOR             2C3144
TREMBLEY                                       EHAFCT                    2C3144
ENGINE MANUFACTURER        MODEL               SERIAL NUMBER             203144
LYCOMING                   ALF-5C2             LF04                      203144
FUEL IDENT.                FUEL FLCW PPH       MANIFCLD FUEL TEMP FAH    2C3144
JET-A HC RATIO C.192        69C.               226.4                     203144
ORIFICE AIRFLOW LB/SEC     PT3 PSIA            TT3 DEG.RANKINE           2C3144
 19.7                       65.C               900.8                     2C3144
SIMULATED THRUST LBS       FUEL-AIR RATIC MEAS.                          2C3144
1950.0                     0.0122                                        203144
SIMULATED INLET PRESSURE PC PSIA                                         203144
12.761                                                                   2C3144
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                               2C3144
519.7                                                                    2C3144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                      2C3144
 59.9                                                                    203144
FILTER AREA .785 SI                                                      203144
CLEAN CK SMOKE NUMBER 0                                                  203144
SMOKE NUMBER          VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH  2C3144
        2.9                 3.C           C.50   11.394           75.0  203144
        0.0                 4.C           C.50   11.354           75.C  203144
        4.5                 7.C           0.50   11.345           75.C  2C3144
        8.8                11.C           C.50   11.354           75.0  203144
GASEOUS EMISSIONS                                                        2C3144
                      FID        NDIR        NDIR      CHEMI     CHEMI   2C3144
                      UHC         CO         CO2        NC        NOX    2C3144
RANGE                  1          2           2          2         2     2C3144
INSTR GAS TEMP        15C.       56.         56.        64.       64.    203144
RAW VALUE MV           38.4      533.8       562.8     248.3     353.0   203144
GAS CONCEN PPM(C)       32.2      236.8      24477.5       25.2      35.9  203144
GAS CONCEN PCT        C.CC32    C.0237      2.4478    0.CC25    0.CC36   203144
EMISSION INDEX         1.30      19.4       3146.         3.4       4.8  2C3144
FUEL-AIR RATIO        C.0120                                             2C3144
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COMBUSTOR RIG TEST                                                                  033134
DATE                         DATA POINT              TEST CELL                      033134
 9/29/77                     C33134                  1                              C33134
INSTRUMENT OPERATOR                                  TEST OPERATOR                  033134
THEMPEY                                              EBARDT                         C33134
ENGINE MANUFACTURER          MODEL                   SERIAL NUMBER                  033134
LYCOMING                     ALF-5C2                 LF04                           033134
FUEL IDENT.                  FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH         C33134
JET-A HC RATIO C.172          787.                   225.8                          C33134
ORIFICE AIRFLOW LB/SEC       PT3 PSIA                TT3 DEG.RANKINE                C33134
 19.0                         75.2                   9C1.7                          033134
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                                   033134
1990.0                       0.0122                                                 033134
SIMULATED INLET PRESSURE TC PSIA                                                    C33134
14.696                                                                              033134
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                          C33134
519.7                                                                               033134
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 033134
 22.0                                                                               033134
FILTER AREA .3E5 SI                                                                 033134
CLEAN CK SMOKE NUMBER 0                                                             033134
SMOKE NUMBER        VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH             C33134
        4.5                 3.0         C.50       11.311             76.0          C33134
        2.3                 4.C         C.50       11.311             76.C          033134
        8.8                 7.C         C.50       11.311             76.C          C33134
       12.9                11.0         C.50       11.311             76.0          033134
GASEOUS EMISSICNS                                                                   033134
                    FIC         NDIR         NCIR         CHEMI        CHEMI        C33134
                    UFC          CC           CC2          NO           NCX         033134
RANGE                1           2            2            2            2           033134
INSTR GAS TEMP      150.        61.          61.          64.          64.          033134
RAW VALUE MV         18.6       445.C        568.5        296.8        409.2        C33134
GAS CONCEN PPM(C)     17.0       19C.5        24683.4        30.5         42.C      C33134
GAS CONCEN PCT      C.CC17      0.0191       2.4683       0.CC30       0.CC42       C33134
EMISSION INDEX       C.68        15.5        3154.          4.1          5.6        033134
FUEL-AIR RATIO      C.C120                                                          C33134
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COMBUSTOR RIG TEST
DATE                        DATA POINT           TEST CELL                 073144
 3/25/77                    073144               1                         073144
INSTRUMENT OPERATOR                              TEST OPERATOR             073144
TREMBLEY                                         EHARDT                    073144
ENGINE MANUFACTURER         MODEL                SERIAL NUMBER             073144
LYCOMING                    ALF-502              LF04                      073144
FUEL IDENT.                 FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH    073144
JET-A HC RATIO 0.192         787.                226.3                     073144
ORIFICE AIRFLOW LB/SEC      PT3 PSIA             TT3 DEG.RANKINE           073144
 17.8                        75.1                501.7                     073144
SIMULATED THRUST LBS        FUEL-AIR RATIO MEAS.                           073144
1950.0                      0.0123                                         073144
SIMULATED INLET PRESSURE PC PSIA                                           073144
14.696                                                                      073144
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                 073144
519.7                                                                       073144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                        073144
 51.1                                                                       073144
FILTER AREA .385 SI                                                        073144
CLEAN CK SMOKE NUMBER 0                                                    073144
SMOKE NUMBER         VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH  073144
         4.9                3.0          0.50     11.365            76.0   073144
         2.3                4.0          0.50     11.365            76.0   073144
        10.9                7.0          0.50     11.365            76.0   073144
        16.9               11.0          0.50     11.365            76.0   073144
GASEOUS EMISSIONS                                                          073144
                     FID        NDIR       NDIR       CHEMI      CHEMI     073144
                     HC          CO         CO2        NO         NOX      073144
RANGE                 1          2          2          2          2        073144
INSTR GAS TEMP       150.       60.        60.        64.        64.       073144
RAW VALUE MV          20.6      452.8      574.7      273.1      383.3     073144
GAS CONCEN PPM(C)      19.8      194.2     24990.2       28.0       39.4   073144
GAS CONCEN PCT       0.0020     0.0194     2.4990     0.0028     0.0039    073144
EMISSION INDEX        0.79       19.6      3154.         3.7        5.2    073144
FUEL-AIR RATIO       0.0122                                                073144
                                                                           073144
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COMBUSTOR AIR TEST                                                              1C3144
DATE                         CATA PCINT           TEST CELL                     1C3144
 3/29/77                     1C3144               1                             103144
INSTRUMENT OPERATOR                               TEST OPERATOR                 103144
TREMBLEY                                          EFARCT                        1C3144
ENGINE MANUFACTURER          MODEL                SERIAL NUMBER                 103144
LYCOMING                     ALF-5C2              LF04                          1C3144
FUEL SPEC.                   FUEL FLCW PPH        MANIFCLC FUEL TEMP FAH        103144
JET-A HC RATIO C.152          783.                226.4                         1C3144
ORIFICE AIRFLOW LB/SEC       PT3 PSIA             TT3 CEG.RANKINE               1C3144
 17.7                         75.1                9CC.8                         103144
SIMULATED THRUST LBS         FUEL-AIR RATIC MEAS.                               1C3144
1999.0                       0.0123                                             103144
SIMULATED INLET PRESSURE PC PSIA                                                1C3144
14.696                                                                          103144
SIMULATED INLET TEMPERATURE TC CEG.RANKINE                                      1C3144
518.7                                                                           103144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             1C3144
 49.9                                                                           1C3144
FILTER AREA .785 SI                                                             103144
FILTER OR SMOKE NUMBER C                                                        1C3144
SMOKE NUMBER          VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH      1C3144
         4.9                  7.C         C.50      11.321              78.C    103144
         6.7                  4.C         C.50      11.321              78.C    103144
         8.8                  7.C         0.50      11.321              78.0    103144
        10.9                 11.C         C.50      11.321              78.C    103144
GASEOUS EMISSIONS                                                               1C3144
                      FID        NDIR       NDIR       CHEMI      CHEMI         103144
                      UHC        CO          CO2       NC         NCX           103144
RANGE                  1         2          2          2          2             103144
SAMPLE GAS TEMP       15C.       58.        58.        64.        64.           103144
RAW VALUE MV          28.9       478.9      574.5      257.2      366.4         1C3144
GAS CONCEN PPMV(C)     37.6      206.C       24583.2       26.4       37.6      103144
GAS CONCEN PCT        C.CC28     C.02C7     2.4583     C.CC26     C.CC38        1C3144
EMISSION INDEX         1.09      16.6       3151.          2.5        5.C       1C3144
FUEL-AIR RATIO        C.C122                                                    103144
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COMBUSTION RIG TEST                                                        162144
DATE                        DATA POINT          TEST CELL                  162144
 [illegible]                163144              1                          163144
INSTRUMENT OPERATOR                             TEST OPERATOR              162144
[illegible]                                     [illegible]                162144
ENGINE MANUFACTURER         MODEL               SERIAL NUMBER              162144
[illegible]                 ALF-502             LF04                       163144
FUEL SPEC.                  FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH     162144
JET-A HC RATIO 0.192         842.               225.7                      162144
COMBUSTOR AIRFLOW LB/SEC    P[illegible] PSIA   T[illegible] DEG.RANKINE   162144
 [illegible]                 [illegible]        901.8                      162144
SIMULATED THRUST LBS        FUEL-AIR RATIO MEAS.                           162144
[illegible]                 0.012C                                         162144
SIMULATED INLET PRESSURE PT PSIA                                           162144
[illegible]                                                                162144
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                 162144
[illegible]                                                                162144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                        162144
 [illegible]                                                               162144
FILTER AREA .[illegible] SF                                                163144
CLEAN CA SMOKE NUMBER 0                                                    162144
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH    162144
        [illegible]          7.0        C.50     11.751             80.0   162144
        [illegible]          4.C        C.50     11.751             80.C   162144
        [illegible]          7.C        C.50     11.751             80.0   162144
       [illegible]          11.0        C.50     11.751             80.0   162144
GASEOUS EMISSIONS                                                          163144
                       FID       NDIR       NDIR       CHEM1      CHEM1    162144
                       UHC       CO         CO2        NO         NOX      162144
RANGE                  1         7          2          2          2        162144
DRIER GAS TEMP         150.      62.        62.        65.        64.      162144
RAW VALUE MV           15.8      665.5      567.6      271.8      285.9    162144
GAS CONCEN PPMVC        71.3     192.0      26664.8        20.0       35.7 162144
GAS CONCEN PCT         0.CC71    C.0197     2.6665     0.CC20     C.CC40   162144
EMISSION INDEX         C.56      15.9       2152.          1.8        5.4  162144
FUEL-AIR RATIO         C.C115                                              162144
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COMBUSTOR RIG TEST                                                                   043134
DATE                             DATA POINT             TEST CELL                    043134
 3/25/77                         043134                 1                            043134
INSTRUMENT OPERATOR                                     TEST OPERATOR                043134
TREMBLEY                                                EFARDT                       043134
ENGINE MANUFACTURER              MODEL                  SERIAL NUMBER                043134
LYCOMING                         ALF-502                LF04                         043134
FUEL IDENT.                      FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH       043134
JET-A HC RATIO 0.152              815.                  225.2                        043134
ORIFICE AIRFLOW LB/SEC           PT3 PSIA               TT3 DEG.RANKINE              043134
 17.5                             75.0                  945.8                        043134
SIMULATED THRUST LBS             FUEL-AIR RATIO MEAS.                                043134
1950.0                           0.0129                                              043134
SIMULATED INLET PRESSURE PO PSIA                                                     043134
14.696                                                                               043134
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                           043134
544.7                                                                                043134
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                  043134
 25.4                                                                                043134
FILTER AREA .385 SI                                                                  043134
CLEAN CK SMOKE NUMBER 0                                                              043134
SMOKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH             043134
         4.5                3.0          0.50     11.346              79.0           043134
         2.3                4.0          0.50     11.346              79.0           043134
         8.8                7.0          0.50     11.346              79.0           043134
        14.9               11.0          0.48     11.297              80.0           043134
GASEOUS EMISSIONS                                                                    043134
                    FID        NDIR       NDIR       CHEMI       CHEMI               043134
                    UHC         CO         CO2        NO          NOX                043134
RANGE                1          2          2          2           2                  043134
INSTR GAS TEMP      150.       57.        57.        64.         64.                 043134
RAW VALUE MV          9.8      384.4      595.8      262.4       472.5               043134
GAS CONCEN PPM(C)    10.5       164.1      26067.7       37.2        48.5            043134
GAS CONCEN PCT      0.0011     0.0164     2.6068     0.0037      0.0048              043134
EMISSION INDEX       0.40       12.7      3159.         4.7         6.1              043134
FUEL-AIR RATIO      0.0127                                                           043134
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                                                                                  C82134
COMBUSTOR RIG TEST                                                                083134
DATE                           DATA POINT             TEST CELL                   C82134
 3/28/77                       C83134                 1                           C82134
INSTRUMENT OPERATCR                                   TEST CPERATCR               C82134
TREMBLFY                                              EHARCT                      C82134
ENGINE MANUFACTLRER            MCDEL                  SERIAL NUMBER               C83134
LYCOMING                       ALF-5C2                LF04                        C83134
FUEL IDENT.                    FUEL FLCW PPH          MANIFCLC FUEL TEMP FAH      C83134
JET-A HC RATIO C.158            816.                  229.0                       C83134
ORIFICE AIRFLOW LB/SEC         PT3 PSIA               TT3 CEG.RANKINE             083134
 18.0                           75.1                  542.7                       C83134
SIMULATED THRUST LBS           FUEL-AIR RATIC MEAS.                               C82134
1950.0                         0.0126                                             083134
SIMULATED INLET PRESSURE FD PSIA                                                  C83134
14.696                                                                            C83134
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                        C82134
544.7                                                                             C83134
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                               083134
 51.4                                                                             C83134
FILTER AREA .385 SI                                                               C83134
CLEAN CK SMOKE NUMBER C                                                           083134
SMOKE NUMBER        VCL.-LITERS      FLCW-CFM PRESS.-PSIA   TEMP. DEG.FAH         C83134
       2.3                 3.C          0.50     11.439               75.0        C83134
       2.3                 4.C          C.50     11.439               75.0        C83134
       6.7                 7.C          C.50     11.39C               75.C        C83134
      10.9                11.0          C.49     11.390               75.C        C83134
GASEOUS EMISSICNS                                                                 083134
                    FIC        NDIR       NCIR        CHEMI      CHEMI            C83134
                    UFC         CO         CC2         NC         NCX             C83134
RANGE                1          2          2          2           2               C83134
INSTR GAS TEMP      151.       64.        64.         64.         64.             C83134
RAW VALUE MV         21.9      439.9      587.3       304.7       419.4           082134
GAS CONCEN PPM(C)     18.3      185.5      25306.3       30.7        42.5         C83134
GAS CONCEN PCT      C.CC18     0.0186     2.5306      0.CC31      0.CC43          C83134
EMISSION INDEX       C.72       14.7      3150.          4.C         5.5          083134
FUEL-AIR RATIO      C.0124                                                        C83134
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COMBUSTOR RIG TEST
DATE                                                                 113144
 3/28/77                  DATA POINT              TEST CELL          113144
INSTRUMENT OPERATOR       113144                  1                  113144
TREMBLEY                                          TEST OPERATOR      113144
ENGINE MANUFACTURER                               EHARDT             113144
LYCOMING                  MODEL                   SERIAL NUMBER      113144
FUEL IDENT.               ALF-502                 LF04               113144
JET-A HC RATIO 0.158      FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH 113144
ORIFICE AIRFLOW LB/SEC     808.                   228.9              113144
 17.6                     PT3 PSIA                TT3 DEG.RANKINE    113144
SIMULATED THRUST LBS       75.4                   942.1              113144
1950.0                    FUEL-AIR RATIO MEAS.                       113144
SIMULATED INLET PRESSURE PO PSIA                                     113144
14.696                    0.0127                                     113144
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                           113144
544.7                                                                113144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                  113144
103.2                                                                113144
FILTER AREA .385 ST                                                  113144
CLEAN CK SMOKE NUMBER 0                                              113144
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH 113144
      2.3                 3.0          0.50      11.383          76.0 113144
      4.5                 4.0          0.50      11.383          76.0 113144
      8.8                 7.0          0.50      11.383          76.0 113144
     10.9                11.0          0.50      11.530          76.0 113144
GASEOUS EMISSIONS                                                    113144
                  FID        NDIR        NDIR       CHEMI      CHEMI  113144
                  UHC        CO          CO2        NO         NOX    113144
RANGE              1          2           2          2          2     113144
INSTR GAS TEMP    152.       58.         58.        64.        64.    113144
RAW VALUE MV       32.3      477.3       594.1      255.7      367.3  113144
GAS CONCEN PPM(C)   26.7      203.5     25639.3       25.6       37.1  113144
GAS CONCEN PCT    0.0027     0.0204      2.5639     0.0026     0.0037  113144
EMISSION INDEX     1.03       15.9       3147.        3.3        4.7   113144
FUEL-AIR RATIO    0.0125                                              113144
                                                                     113144
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COMBUSTOR RIG TEST                                                                  133154
DATE                           DATA POINT              TEST CELL                    133154
 3/28/77                       133154                  1                            133154
INSTRUMENT OPERATOR                                    TEST OPERATOR                133154
TREMBLEY                                               EFARCT                       133154
ENGINE MANUFACTURER            MODEL                   SERIAL NUMBER                133154
LYCOMING                       ALF-502                 LFC4                         133154
FUEL IDENT.                    FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH       133154
JET-A HC RATIO 0.158            812.                   226.4                        133154
ORIFICE AIRFLOW LB/SEC         PT3 PSIA                TT3 DEG.RANKINE              133154
 17.0                           75.1                   944.0                        133154
SIMULATED THRUST LBS           FUEL-AIR RATIO MEAS.                                 133154
1950.0                         0.0132                                               133154
SIMULATED INLET PRESSURE PO PSIA                                                    133154
14.696                                                                              133154
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                          133154
544.7                                                                               133154
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 133154
175.0                                                                               133154
FILTER AREA .385 SI                                                                 133154
CLEAN CK SMOKE NUMBER 0                                                             133154
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              133154
        4.5                3.0          0.50     11.333              74.0           133154
        4.5                4.0          0.50     11.333              73.0           133154
        6.7                7.0          0.50     11.358              74.0           133154
        6.7               11.0          0.50     11.284              75.0           133154
GASEOUS EMISSIONS                                                                   133154
                   FID         NDIR        NDIR        CHEMI       CHEMI            133154
                   UHC          CO          CO2         NO          NOX             133154
RANGE               1           2           2           2           2               133154
INSTR GAS TEMP     151.        52.         52.         64.         64.              133154
RAW VALUE MV        44.4       458.5       602.6       229.1       327.0            133154
GAS CONCEN PPM(C)    37.4       217.5      26291.5        22.4        32.3          133154
GAS CONCEN PCT     0.0037      0.0218      2.6291      0.0022      0.0032           133154
EMISSION INDEX      1.41        16.5       3135.          2.8         4.0           133154
FUEL-AIR RATIO     0.0129                                                           133154
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COMBUSTOR RIG TEST                                                               104134
DATE                            DATA POINT                 TEST CELL             104134
 2/30/77                        104134                     1                     104134
INSTRUMENT OPERATOR                                        TEST OPERATOR         104134
TREMBLEY                                                   EFARCT                104134
ENGINE MANUFACTURER             MODEL                      SERIAL NUMBER         104134
LYCOMING                        ALF-502                    LF04                  104134
FUEL IDENT.                     FUEL FLOW PPH              MANIFOLD FUEL TEMP FAH 104134
JET-A HC RATIO 0.160            1116.                      224.6                 104134
ORIFICE AIRFLOW LB/SEC          PT3 PSIA                   TT3 DEG.RANKINE       104134
 21.6                            56.5                      964.1                 104134
SIMULATED THRUST LBS            FUEL-AIR RATIO MEAS.                             104134
2900.0                          0.0144                                           104134
SIMULATED INLET PRESSURE PO PSIA                                                 104134
14.696                                                                           104134
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                       104134
518.7                                                                            104134
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                              104134
 70.4                                                                            104134
FILTER AREA .385 SI                                                              104134
CLEAN CK SMOKE NUMBER 0                                                          104134
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          104134
        2.3                 3.0         0.50      11.354           74.0          104134
       10.9                 4.0         0.50      11.379           74.0          104134
       14.9                 7.0         0.50      11.354           74.0          104134
       27.5                11.0         0.50      11.379           74.0          104134
GASEOUS EMISSIONS                                                                104134
                    FID        NDIR       NDIR       CHEMI      CHEMI            104134
                    UHC        CO         CO2        NO         NOX              104134
RANGE                1          2          2          2          2               104134
INSTR GAS TEMP      128.       59.        59.        64.        64.              104134
RAW VALUE MV          5.0      242.0      665.4      454.0      529.1            104134
GAS CONCEN PPM(C)     3.5      106.0    29507.1       46.1       53.8            104134
GAS CONCEN PCT      0.0003     0.0106     2.9507     0.0046     0.0054           104134
EMISSION INDEX      0.12         7.2      3148.         5.1        6.0           104134
FUEL-AIR RATIO      0.0144                                                       104134
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                                                                         223154
COMBUSTOR RIG TEST                                                       223154
DATE                         DATA POINT            TEST CELL             223154
 3/28/77                     223154                1                     223154
INSTRUMENT OPERATOR                                TEST OPERATOR         223154
TREMBLEY                                           EHARDT                223154
ENGINE MANUFACTURER          MODEL                 SERIAL NUMBER         223154
LYCOMING                     ALF-502               LFC4                  223154
FUEL IDENT.                  FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH 223154
JET-A HC RATIO 0.158          723.                 224.8                 223154
ORIFICE AIRFLOW LB/SEC       PT3 PSIA              TT3 DEG.RANKINE       223154
 14.3                         65.5                 579.3                 223154
SIMULATED THRUST LBS         FUEL-AIR RATIO MEAS.                        223154
1950.0                       0.0141                                      223154
SIMULATED INLET PRESSURE PO PSIA                                         223154
12.761                                                                   223154
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                               223154
564.7                                                                    223154
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                      223154
177.5                                                                    223154
FILTER AREA .385 SI                                                      223154
CLEAN CK SMOKE NUMBER 0                                                  223154
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH  223154
     4.5                    3.0        0.50      11.353            72.0  223154
     2.3                    4.0        0.50      11.353            72.0  223154
     4.5                    7.0        0.50      11.353            72.0  223154
     6.7                   11.0        0.50      11.353            72.0  223154
GASEOUS EMISSIONS                                                        223154
                  FID      NDIR      NDIR       CHEMI      CHEMI         223154
                  UHC       CO        CO2        NO         NOX          223154
RANGE              1        2         2          2          2            223154
INSTR GAS TEMP    151.     59.       59.        64.        62.           223154
RAW VALUE MV      30.9     465.3     651.0      250.3      355.6         223154
GAS CONCEN PPM(C)  26.6     198.8     28414.5      25.4       36.2       223154
GAS CONCEN PCT    0.0027   0.0199    2.8414     0.0025     0.0036        223154
EMISSION INDEX     0.93     14.0     3140.         2.5        4.2        223154
FUEL-AIR RATIO    0.0139                                                 223154
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COMBUSTOR RIG TEST                                                                          C93134
DATE                                  DATA POINT               TEST CELL                    093134
 3/28/77                              C93134                   1                            C93134
INSTRUMENT OPERATCR                                            TEST OPERATCR                093134
TREMBLEY                                                       EFARDT                       C93134
ENGINE MANUFACTURER                   MODEL                    SERIAL NUMBER                C93134
LYCOMING                              ALF-502                  LF04                         C93134
FUEL IDENT.                           FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH       C93134
JET-A HC RATIO C.158                   836.                    224.9                        093134
ORIFICE AIRFLOW LB/SEC                FT3 PSIA                 TT3 DEG.RANKINE              093134
 17.3                                  75.3                    980.8                        093134
SIMULATED THRUST LBS                  FUEL-AIR RATIC MEAS.                                  C93134
1950.0                                0.0134                                                093134
SIMULATED INLET PRESSURE PO PSIA                                                            C93134
14.696                                                                                      C93134
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                                  C93134
564.7                                                                                       C93134
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                         C93134
 57.0                                                                                       093134
FILTER AREA .385 SI                                                                         C93134
CLEAN CK SMOKE NUMBER 0                                                                     093134
SMOKE NUMBER          VCL.-LITERS      FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH                 C93134
         4.5                  3.0           C.50     11.338            75.C                 C93134
         2.3                  4.C           C.49     11.314            73.C                 C93134
         8.8                  7.C           C.50     11.363            73.C                 093134
        12.9                 11.0           C.50     11.363            73.C                 C93134
GASEOUS EMISSIONS                                                                           093134
                      FID          NDIR         NDIR         CHEMI        CHEMI             C93134
                      UFC          CO           CO2          NO           NOX               C93134
RANGE                  1           2            2            2            2                 093134
INSTR GAS TEMP        151.         46.          46.          63.          63.               C93134
RAW VALUE MV           12.2        352.6        621.7        377.8        488.1             C93134
GAS CONCEN PPM(C)        9.4        150.1        27242.4        37.5         48.7           093134
GAS CONCEN PCT        C.CCC9       0.0150       2.7242       0.CC37       0.CC49            C93134
EMISSION INDEX        C.34         11.0         3147.           4.5          5.9            C93134
FUEL-AIR RATIO        0.C133                                                                C93134
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COMBUSTOR RIG TEST                                                  123144
DATE                       DATA POINT            TEST CELL          123144
 3/28/77                   123144                1                  123144
INSTRUMENT OPERATOR                              TEST OPERATOR      123144
TREMBLEY                                         EHARDT             123144
ENGINE MANUFACTURER        MODEL                 SERIAL NUMBER      123144
LYCOMING                   ALF-502               LF04               123144
FUEL IDENT.                FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH  123144
JET-A HC RATIO 0.158        832.                 225.4              123144
ORIFICE AIRFLOW LB/SEC     PT3 PSIA              TT3 DEG.RANKINE    123144
 17.0                       75.2                 979.8              123144
SIMULATED THRUST LBS       FUEL-AIR RATIO MEAS.                     123144
1950.0                     0.0136                                   123144
SIMULATED INLET PRESSURE PO PSIA                                    123144
14.696                                                              123144
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                          123144
564.7                                                               123144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                 123144
104.8                                                               123144
FILTER AREA .385 SI                                                 123144
CLEAN CK SMOKE NUMBER 0                                             123144
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   123144
       4.5                3.0          0.52     11.392          72.0   123144
       4.5                4.0          0.50     11.392          72.0   123144
       6.7                7.0          0.50     11.392          72.0   123144
      12.9               11.0          0.50     11.417          72.0   123144
GASEOUS EMISSIONS                                                   123144
                    FID        NDIR        NDIR       CHEMI      CHEMI   123144
                    UHC         CO          CO2        NO         NOX    123144
RANGE                1          2           2          2          2      123144
INSTR GAS TEMP      151.       42.         43.        63.        64.     123144
RAW VALUE MV         15.5      368.4       631.2      325.8      429.3   123144
GAS CONCEN PPM(C)     12.6      156.7      27709.1       32.2       42.7  123144
GAS CONCEN PCT      0.0013     0.0157      2.7709     0.0032     0.0043  123144
EMISSION INDEX       0.45       11.3       3146.         3.8        5.1  123144
FUEL-AIR RATIO      0.0136                                          123144
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COMBUSTOR RIG TEST
DATE                                                                         143154
  3/28/77                DATA POINT            TEST CELL                     143154
INSTRUMENT OPERATOR      143154                1                             143154
TREMBLEY                                       TEST OPERATOR                 143154
ENGINE MANUFACTURER      MODEL                 EFARET                        143154
LYCOMING                 ALF-502               SERIAL NUMBER                 143154
FUEL IDENT.              FUEL FLOW PPH         LFC4                          143154
JET-A HC RATIO 0.158      832.                 MANIFOLD FUEL TEMP FAH        143154
ORIFICE AIRFLOW LB/SEC   PT3 PSIA              226.4                         143154
  16.7                    75.4                 TT3 DEG.RANKINE               143154
SIMULATED THRUST LBS     FUEL-AIR RATIO MEAS.  579.7                         143154
1950.0                   0.0138                                              143154
SIMULATED INLET PRESSURE PC PSIA                                             143154
14.696                                                                       143154
SIMULATED INLET TEMPERATURE TC DEG.RANKINE                                   143154
564.7                                                                        143154
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                          143154
173.6                                                                        143154
FILTER AREA .385 SI                                                          143154
CLEAN CK SMOKE NUMBER 0                                                      143154
SMOKE NUMBER         VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH     143154
        4.5                  3.0         0.50     11.397            73.0     143154
        2.3                  4.0         0.50     11.348            73.0     143154
        6.7                  7.0         0.50     11.348            72.0     143154
       10.9                 11.0         0.50     11.373            72.0     143154
GASEOUS EMISSIONS                                                            143154
                   FIC        NDIR        NDIR        CHEMI      CHEMI       143154
                   UFC         CO          CO2         NO         NOX        143154
RANGE               1          2           2           2          2          143154
INSTR GAS TEMP     151.       67.         67.         63.        64.         143154
RAW VALUE MV        24.9     410.6       637.2       268.6      366.8        143154
GAS CONCEN PPM(C)   20.7     175.0     27999.5        26.4       36.4        143154
GAS CONCEN PCT     0.0021    0.0175      2.8000      0.0026     0.0036       143154
EMISSION INDEX      0.74      12.5     3143.          3.1        4.3         143154
FUEL-AIR RATIO     0.0137                                                    143154
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COMBUSTOR RIG TEST
DATE                          DATA POINT           TEST CELL                     183154
 3/28/77                      183154               1                             183154
INSTRUMENT OPERATOR                                                              183154
TREMBLEY                                           TEST OPERATOR                 183154
ENGINE MANUFACTURER           MODEL                EHARDT                        183154
LYCOMING                      ALF-502              SERIAL NUMBER                 183154
FUEL IDENT.                                        LFC4                          183154
JET-A HC RATIO 0.158          FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH        183154
ORIFICE AIRFLOW LB/SEC         893.                223.9                         183154
 18.7                         PT3 PSIA             TT3 DEG.RANKINE               183154
SIMULATED THRUST LBS           81.0                975.8                         183154
1950.0                        FUEL-AIR RATIO MEAS.                               183154
                              0.0133                                             183154
SIMULATED INLET PRESSURE PO PSIA                                                 183154
15.855                                                                           183154
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                       183154
564.7                                                                            183154
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                              183154
173.4                                                                            183154
FILTER AREA .385 SI                                                              183154
CLEAN CK SMOKE NUMBER 0                                                          183154
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       183154
      2.3                    3.0          0.50      11.354                       183154
      2.3                    4.0          0.50      11.591            74.0      183154
      6.7                    7.0          0.50      11.354            74.0      183154
     10.9                   11.0          0.50      11.591            74.0      183154
GASEOUS EMISSIONS                                                     74.0      183154
                                                                                183154
                    FID       NDIR       NDIR        CHEMI      CHEMI           183154
                    UHC       CO         CO2         NO         NOX             183154
RANGE                1        2          2           2          2               183154
INSTR GAS TEMP      152.      58.        58.         64.        64.             183154
RAW VALUE MV         32.6     455.4      624.9       248.3      360.6           183154
GAS CONCEN PPM(C)     27.8     194.0      27138.1       25.2       36.8         183154
GAS CONCEN PCT      0.0028    0.0194     2.7138      0.0025     0.0037          183154
EMISSION INDEX       1.02      14.3      3139.          3.1        4.4          183154
FUEL-AIR RATIO      0.0133                                                      183154
                                                                                183154
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                                                                                     114144
COMBUSTOR RIG TEST                                                                   114144
DATE                        DATA POINT              TEST CELL                        114144
 2/30/77                    114144                  1                                114144
INSTRUMENT OPERATOR                                 TEST OPERATOR                    114144
TREMBLEY                                            EHARDT                           114144
ENGINE MANUFACTURER         MODEL                   SERIAL NUMBER                    114144
LYCOMING                    ALF-5C2                 LF04                             114144
FUEL IDENT.                 FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH           114144
JET-A HC RATIO 0.160        1116.                   223.4                            114144
ORIFICE AIRFLOW LB/SEC      PT3 PSIA                TT3 DEG.RANKINE                  114144
 20.5                        96.6                   1012.                            114144
SIMULATED THRUST LBS        FUEL-AIR RATIO MEAS.                                     114144
2900.0                      0.0151                                                   114144
SIMULATED INLET PRESSURE PO PSIA                                                     114144
14.696                                                                               114144
SIMULATED INLET TEMPERATURE TO DEG.RANKINE                                           114144
544.7                                                                                114144
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                  114144
106.4                                                                                114144
GASEOUS EMISSIONS                                                                    114144
                     FID          NDIR         NDIR         CHEMI        CHEMI       114144
                     UHC           CO          CO2           NO           NOX        114144
 RANGE                1             1            2            2            2         114144
 INSTR GAS TEMP      138.          60.          60.          64.          64.        114144
 RAW VALUE MV          2.5        768.4        717.6        496.5        555.5       114144
 GAS CONCEN PPM(C)       1.6         68.2       32232.0         50.1         56.1    114144
 GAS CONCEN PCT      0.0002       0.0068       3.2232       0.0050       0.0056      114144
 EMISSION INDEX      0.05           4.2        3153.           5.1          5.7      114144
 FUEL-AIR RATIO      0.0158
```

APPENDIX C

ENGINE DATA

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ENGINE TEST DATA                                                                221101
DATE                         DATA POINT           TEST CELL                     221101
08/11/76                     221101               13                            221101
INSTRUMENT OPERATOR                               TEST OPERATOR                 221101
ERHARDT                                           TREMBLEY                      221101
ENGINE MANUFACTURER          MODEL                SERIAL NUMBER                 221101
LYCOMING                     ALF-502              LF02                          221101
FUEL IDENT.                  FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH        221101
JET-A HC RATIO 0.161          411.                166.6                         221101
BELLMOUTH AIR FLOW LB/SEC    CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.          221101
 68.1                         9.7                 0.0118                        221101
PT3 PSIA                     TT3 DEG. RANKINE                                   221101
 34.4                         720.5                                             221101
PT9 PSIA                     TT9 DEG RANKINE      EPR                           221101
14.985                       1255.6                2.32                         221101
NET THRUST LBS               N1 RPM               N2 RPM                        221101
 412.0                       11104.               1903.                         221101
ACTUAL INLET PRESSURE PO PSIA                                                   221101
14.797                                                                          221101
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                        221101
537.6                                                                           221101
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             221101
101.4                                                                           221101
FILTER AREA .385 SI                                                             221101
CLEAN CK SMOKE NUMBER 0                                                         221101
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       221101
         2.3                  3.0         0.45      11.650             85.0     221101
         2.3                  4.0         0.47      11.847             85.0     221101
         2.3                  7.0         0.47      11.847             85.0     221101
         2.3                 11.0         0.45      11.847             85.0     221101
GASEOUS EMISSIONS                                                               221101
                     FID       NDIR        NDIR        CHEMI      CHEMI         221101
                     UHC       CO          CO2         NO         NOX           221101
RANGE                2         3           2           1          1             221101
INSTR GAS TEMP       153.      55.         55.         62.        62.           221101
RAW VALUE MV          19.0     422.6       513.8       532.7      766.6         221101
GAS CONCEN PPM(C)    139.2      509.5       22237.0       13.6       19.4       221101
GAS CONCEN PCT       0.0139    0.0509      2.2237      0.0014     0.0019        221101
EMISSION INDEX         6.08     44.7       3065.          1.9        2.8        221101
FUEL-AIR RATIO       0.0111                                                     221101
```

```
ENGINE TEST DATA
DATE                          DATA POINT              TEST CELL                     226701
08/11/76                      226701                  13                            226701
INSTRUMENT OPERATOR                                   TEST OPERATOR                 226701
ERHARDT                                               TREMBLEY                      226701
ENGINE MANUFACTURER           MODEL                   SERIAL NUMBER                 226701
LYCOMING                      ALF-502                 LF02                          226701
FUEL IDENT.                   FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH        226701
JET-A HC RATIO 0.161          2517.                   236.7                         226701
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC     FUEL-AIR RATIO MEAS.          226701
232.5                         33.7                    0.0208                        226701
PT3 PSIA                      TT3 DEG. RANKINE                                      226701
153.4                        1161.2                                                 226701
FT9 PSIA                      TT9 DEG RANKINE         EPR                           226701
18.317                        1612.3                  10.40                         226701
NET THRUST LBS                N1 RPM                  N2 RPM                        226701
6003.0                        19402.                  6210.                         226701
ACTUAL INLET PRESSURE PO PSIA                                                       226701
14.710                                                                              226701
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                            226701
536.2                                                                               226701
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 226701
 99.5                                                                               226701
FILTER AREA .385 SI                                                                 226701
CLEAN CK SMOKE NUMBER 0                                                             226701
SMOKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH            226701
        24.1                3.0          0.52     13.565            88.0            226701
        22.4                4.0          0.53     13.467            87.0            226701
        32.4                7.0          0.53     13.418            89.0            226701
        38.3               11.0          0.52     13.270            89.0            226701
GASEOUS EMISSIONS                                                                   226701
                   FID        NDIR        NDIR       CHEMI       CHEMI              226701
                   UHC         CO          CO2        NO          NOX               226701
RANGE               1          1           2          3           3                 226701
INSTR GAS TEMP     153.        52.         52.        61.         61.               226701
RAW VALUE MV         6.5       103.6       922.1      420.6       443.3             226701
GAS CONCEN PPM(C)    4.2         7.6      44278.1       107.6       113.4           226701
GAS CONCEN PCT     0.0004      0.0008      4.4278     0.0108      0.0113            226701
EMISSION INDEX      0.09         0.3       3154.         8.0         8.4            226701
FUEL-AIR RATIO     0.0218                                                           226701
                                                                                    226701
```

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ENGINE TEST DATA
CATE
C8/11/76                     CATA PCINT            TEST CELL                         228601
                             228601                13                                228601
INSTRUMENT OPERATOR                                                                  228601
ERHARCT                                            TEST OPERATOR                     228601
ENGINE MANUFACTURER                                TREMBLEY                          228601
LYCOMING                     MODEL                 SERIAL NUMBER                     228601
FUEL IDENT.                  ALF-502               LF02                              228601
JET-A HC RATIO 0.161         FUEL FLCW PPH         MANIFCLD FUEL TEMP FAH            228601
BELLMCUTH AIR FLOW LB/SEC    2234.                 252.2                             228601
220.7                        CCRE AIRFLOW LB/SEC   FUEL-AIR RATIO MEAS.              228601
PT3 PSIA                     31.9                  0.0195                            228601
142.8                        TT3 DEG. RANKINE                                        228601
PT9 PSIA                    1138.5                                                   228601
17.792                       TT9 DEG RANKINE       EPR                               228601
NET THRUST LBS               1563.0                 9.72                             228601
5402.0                       N1 RFM                N2 RPM                            228601
ACTUAL INLET PRESSURE PO PSIA 19078.               6472.                             228601
14.701                                                                               228601
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                             228601
536.6                                                                                228601
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                  228601
 92.8                                                                                228601
FILTER AREA .385 SI                                                                  228601
CLEAN CK SMCKE NUMBER 0                                                              228601
SMOKE NUMBER        VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH              228601
       18.7                 3.0         0.53     13.314             88.0             228601
       22.4                 4.0         0.53     13.314             87.0             228601
       32.4                 7.0         0.52     13.314             88.0             228601
       39.7                11.0         0.50     13.265             88.0             228601
GASEOUS EMISSIONS                                                                    228601
                    FID         NDIR        NCIR        CHEMI       CHEMI            228601
                    UHC         CO          CO2         NO          NOX              228601
RANGE               1           1           2           3           3                228601
INSTR GAS TEMP      153.        53.         53.         62.         62.              228601
RAW VALUE MV          6.1         83.6      867.0       361.1       385.4            228601
GAS CCNCEN PPM(C)       1.8          6.8    41824.6        91.1        97.3          228601
GAS CCNCEN PCT      0.0002      0.CCC7      4.1825      C.CC91      0.0097           228601
EMISSICN INDEX        0.04         0.3      3154.          7.2         7.7           228601
FUEL-AIR RATIC      C.02C6                                                           228601
                                                                                     228601
```

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ENGINE TEST DATA
DATE                                                                        227501
08/11/76                       DATA POINT           TEST CELL               227501
INSTRUMENT OPERATOR            227501               13                      227501
ERHARDT                                             TEST OPERATOR           227501
ENGINE MANUFACTURER                                 TREMBLEY                227501
LYCOMING                       MODEL                SERIAL NUMBER           227501
FUEL IDENT.                    ALF-502              LF02                    227501
JET-A HC RATIO 0.161           FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH  227501
BELLMOUTH AIR FLOW LB/SEC      1262.                239.7                   227501
171.8                          CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.    227501
PT3 PSIA                       24.6                 0.0143                  227501
100.5                          TT3 DEG. RANKINE                             227501
PT9 PSIA                      1015.9                                        227501
16.212                         TT9 DEG RANKINE      EPR                     227501
NET THRUST LBS                 1354.6                6.82                   227501
3082.0                         N1 RPM               N2 RPM                  227501
ACTUAL INLET PRESSURE PO PSIA  17276.               4706.                   227501
14.735                                                                      227501
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                    227501
536.2                                                                       227501
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         227501
 94.2                                                                       227501
FILTER AREA .385 SI                                                         227501
CLEAN CK SMOKE NUMBER 0                                                     227501
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH     227501
       14.9                 3.0         0.53      11.939             88.0   227501
       12.9                 4.0         0.55      11.841             88.0   227501
       22.4                 7.0         0.53      11.841             88.0   227501
       29.2                11.0         0.52      11.890             88.0   227501
GASEOUS EMISSIONS                                                           227501
                    FID        NDIR       NDIR        CHEMI      CHEMI      227501
                    UHC         CO         CO2         NO         NOX       227501
RANGE                1          1           2           2          2        227501
INSTR GAS TEMP      154.       53.         53.         62.        62.       227501
RAW VALUE MV          7.4     334.7       642.4       495.1      536.7      227501
GAS CONCEN PPM(C)       2.7       31.0     29259.1        53.1       57.6   227501
GAS CONCEN PCT      0.0003    0.0031      2.9259      0.0053     0.0058     227501
EMISSION INDEX        0.09       2.1      3151.          6.0        6.5     227501
FUEL-AIR RATIO      0.0143                                                  227501
                                                                            227501
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ENGINE TEST CATA
CATE                                                                   224401
C8/11/76                DATA POINT              TEST CELL              224401
INSTRUMENT OPERATOR     224401                  13                     224401
ERHARCT                                         TEST CPERATOR          224401
ENGINE MANUFACTURER                             TREMBLEY               224401
LYCOMING                MODEL                   SERIAL NUMBER          224401
FUEL IDENT.             ALF-502                 LF02                   224401
JET-A HC RATIO 0.161    FUEL FLCW PPH           MANIFOLD FUEL TEMP FAH 224401
BELLMCUTH AIR FLOW LB/SEC 1074.                 231.4                  224401
159.1                   CORE AIRFLCW LB/SEC     FUEL-AIR RATIO MEAS.   224401
PT3 PSIA                22.4                    0.0133                 224401
 90.2                   TT3 DEG. RANKINE                               224401
PT9 PSIA                 981.0                                         224401
15.943                  TT9 DEG RANKINE         EPR                    224401
NET THRUST LBS          1305.5                   6.12                  224401
2568.C                  N1 RPM                  N2 RPM                 224401
                        16742.                  4319.                  224401
ACTUAL INLET PRESSURE PO PSIA                                          224401
14.745                                                                 224401
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                               224401
535.5                                                                  224401
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                    224401
106.1                                                                  224401
FILTER AREA .385 SI                                                    224401
CLEAN CK SMCKE NUMBER 0                                                224401
SMOKE NUMBER       VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH 224401
        10.9               3.0          0.52     12.233           86.0 224401
        12.9               4.0          0.52     12.283           85.0 224401
        22.4               7.0          0.50     12.283           86.0 224401
        29.2              11.0          0.52     12.283           85.0 224401
GASEOLS EMISSIONS                                                      224401
                   FID        NDIR        NDIR       CHEMI     CHEMI   224401
                   UHC         CC          CO2        NO        NOX    224401
RANGE               1          1           2          2         2      224401
INSTR GAS TEMP     153.       53.         53.        62.       62.     224401
RAW VALUE MV         7.4     560.0       598.3      405.9     460.1    224401
GAS CCNCEN PPM(C)     2.4       55.2    26992.9        43.9      49.8  224401
GAS CCNCEN PCT     C.C002     0.CC55      2.6993     0.0044    0.C050  224401
EMISSICN INDEX      0.09        4.1      3148.          5.4       6.1  224401
FUEL-AIR RATIO     C.C132                                              224401
                                                                       224401
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ENGINE TEST DATA                                                                  223301
DATE                          DATA POINT               TEST CELL                  223301
08/11/76                      223301                   13                         223301
INSTRUMENT OPERATOR                                    TEST OPERATOR              223301
ERHARDT                                                TREMBLEY                   223301
ENGINE MANUFACTURER           MODEL                    SERIAL NUMBER              223301
LYCOMING                      ALF-502                  LF02                       223301
FUEL IDENT.                   FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH     223301
JET-A HC RATIO 0.161           743.                    221.2                      223301
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC      FUEL-AIR RATIO MEAS.       223301
128.4                         18.3                     0.0113                     223301
PT3 PSIA                      TT3 DEG. RANKINE                                    223301
 70.2                          891.8                                              223301
PT9 PSIA                      TT9 DEG RANKINE          EPR                        223301
15.508                        1209.1                    4.76                      223301
NET THRUST LBS                N1 RPM                   N2 RPM                     223301
1658.0                        15410.                   3526.                      223301
ACTUAL INLET PRESSURE PO PSIA                                                     223301
14.768                                                                            223301
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                          223301
536.1                                                                             223301
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                               223301
104.1                                                                             223301
FILTER AREA .385 SI                                                               223301
CLEAN CK SMOKE NUMBER 0                                                           223301
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH            223301
       6.7                3.0         0.52     11.989             85.0            223301
       6.7                4.0         0.53     11.989             84.0            223301
      10.9                7.0         0.53     11.989             84.0            223301
      14.9               11.0         0.52     11.989             84.0            223301
GASEOUS EMISSIONS                                                                 223301
                   FID        NDIR       NDIR        CHEMI       CHEMI            223301
                   UHC         CO         CO2         NO          NOX             223301
RANGE               1          2          2           2           2               223301
INSTR GAS TEMP     154.       53.        53.         62.         62.              223301
RAW VALUE MV        21.9      314.3      509.0       267.3       334.6            223301
GAS CONCEN PPM(C)    13.1      132.3      22448.8       29.0        36.2          223301
GAS CONCEN PCT     0.0013     0.0132     2.2449      0.0029      0.0036           223301
EMISSION INDEX      0.58      11.8       3134.         4.2         5.3            223301
FUEL-AIR RATIO     0.0110                                                         223301
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ENGINE TEST CATA                                                                         222201
CATE                          DATA PCINT                TEST CELL                        222201
C8/11/76                      222201                    13                               222201
INSTRUMENT CPERATOR                                     TEST OPERATOR                    222201
ERHARCT                                                 TREMBLEY                         222201
ENGINE MANUFACTURER           MCDEL                     SERIAL NUMBER                    222201
LYCCMING                      ALF-502                   LF02                             222201
FUEL IDENT.                   FUEL FLCW PPH             MANIFOLC FUEL TEMP FAH           222201
JET-A HC RATIO 0.161           457.                     188.6                            222201
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.                   222201
 80.7                         11.6                      0.0109                           222201
PT3 PSIA                      TT3 CEG. RANKINE                                           222201
 40.8                          762.9                                                     222201
PT9 PSIA                      TT9 DEG RANKINE           EPR                              222201
15.057                        1231.6                     2.76                            222201
NET THRUST LBS                N1 RPM                    N2 RPM                           222201
 616.0                        12398.                    2218.                            222201
ACTUAL INLET PRESSURE FO PSIA                                                            222201
14.769                                                                                   222201
ACTUAL INLET TEMPERATURE TO CEG. RANKINE                                                 222201
536.4                                                                                    222201
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                      222201
104.1                                                                                    222201
FILTER AREA .385 SI                                                                      222201
CLEAN CK SMOKE NUMBER 0                                                                  222201
SMCKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH                 222201
        0.0                 3.0          0.50      11.940            85.0                222201
        2.3                 4.0          C.52      11.940            84.0                222201
        2.3                 7.0          0.50      11.891            84.0                222201
        4.5                11.0          C.52      11.842            85.0                222201
GASEOUS EMISSIONS                                                                        222201
                    FID         NDIR        NDIR        CHEMI        CHEMI               222201
                    UHC          CC          CO2         NO           NOX                222201
RANGE                1           2            2          1            1                  222201
INSTR GAS TEMP      153.         52.          52.        62.          62.                222201
RAW VALUE MV         9C.5        719.3        509.5      580.8        896.2              222201
GAS CCNCEN PPM(C)      64.0       355.0      22473.4        14.9        22.7             222201
GAS CCNCEN PCT      0.0064      0.C355      2.2473     0.0015       0.0023               222201
EMISSION INCEX        2.79       31.1       3097.         2.1          3.3               222201
FUEL-AIR RATIC      C.C112                                                               222201
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ENGINE TEST DATA                                                                      221111
DATE                     DATA POINT               TEST CELL                           221111
08/11/76                 221111                   13                                  221111
INSTRUMENT OPERATOR                               TEST OPERATOR                       221111
ERHARDT                                           TREMBLEY                            221111
ENGINE MANUFACTURER      MODEL                    SERIAL NUMBER                       221111
LYCOMING                 ALF-502                  LF02                                221111
FUEL IDENT.              FUEL FLOW PPH            MANIFOLD FUEL TEMP FAH              221111
JET-A HC RATIO 0.161      380.                    172.0                               221111
BELLMOUTH AIR FLOW LB/SEC CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.                    221111
 67.6                     9.5                     0.0111                              221111
PT3 PSIA                 TT3 DEG. RANKINE                                             221111
 33.7                     714.6                                                       221111
PT9 PSIA                 TT9 DEG RANKINE          EPR                                 221111
14.979                   1252.9                    2.28                               221111
NET THRUST LBS           N1 RPM                   N2 RPM                              221111
 413.0                   10960.                   1854.                               221111
ACTUAL INLET PRESSURE PO PSIA                                                         221111
14.780                                                                                221111
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                              221111
535.6                                                                                 221111
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                   221111
105.9                                                                                 221111
FILTER AREA .385 SI                                                                   221111
CLEAN CK SMOKE NUMBER 0                                                               221111
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH               221111
        2.3                 3.0          0.50     11.893            85.0              221111
        2.3                 4.0          0.50     11.893            84.0              221111
        2.3                 7.0          0.50     11.844            85.0              221111
        2.3                11.0          0.49     11.844            85.0              221111
GASEOUS EMISSIONS                                                                     221111
                    FID        NDIR        NDIR        CHEMI       CHEMI              221111
                    UHC        CO          CO2         NO          NOX                221111
RANGE               1          2           2           1           1                  221111
INSTR GAS TEMP      154.       52.         52.         62.         62.                221111
RAW VALUE MV        143.1      888.3       515.5       465.0       793.5              221111
GAS CONCEN PPM(C)    103.0      449.1       22775.5        12.0        20.2           221111
GAS CONCEN PCT      0.0103     0.0449      2.2776      0.0012      0.0020             221111
EMISSION INDEX       4.41       38.7       3080.          1.7         2.9             221111
FUEL-AIR RATIO      0.0114                                                            221111
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ENGINE TEST DATA                                                                   231102
DATE                             DATA POINT           TEST CELL                    231102
08/11/76                         231102               13                           231102
INSTRUMENT OPERATOR                                   TEST OPERATOR                231102
ERHARDT                                               TREMBLEY                     231102
ENGINE MANUFACTURER              MODEL                SERIAL NUMBER                231102
LYCOMING                         ALF-502              LF02                         231102
FUEL IDENT.                      FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH       231102
JET-A HC RATIO 0.161              392.                164.5                        231102
BELLMOUTH AIR FLOW LB/SEC        CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.         231102
 67.5                             9.6                 0.0114                       231102
PT3 PSIA                         TT3 DEG. RANKINE                                  231102
 34.1                             712.7                                            231102
PT9 PSIA                         TT9 DEG RANKINE      EPR                          231102
14.992                           1246.4                2.30                        231102
NET THRUST LBS                   N1 RPM               N2 RPM                       231102
 422.0                           11006.               1880.                        231102
ACTUAL INLET PRESSURE PO PSIA                                                      231102
14.795                                                                             231102
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                           231102
532.6                                                                              231102
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                231102
115.8                                                                              231102
FILTER AREA .385 SI                                                                231102
CLEAN CK SMOKE NUMBER 0                                                            231102
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          231102
           2.3                3.0         0.50      11.850           82.0          231102
           2.3                4.0         0.49      11.800           82.0          231102
           2.3                7.0         0.48      11.800           82.0          231102
           2.3               11.0         0.49      11.800           83.0          231102
GASEOUS EMISSIONS                                                                  231102
                      FID        NDIR        NDIR         CHEMI       CHEMI        231102
                      UHC         CO          CO2          NO          NOX         231102
RANGE                 1           2           2            1           1           231102
INSTR GAS TEMP        153.        56.         56.          62.         62.         231102
RAW VALUE MV          154.7       897.0       512.5        457.2       781.9       231102
GAS CONCEN PPM(C)      112.2       456.3       22805.5        11.7        19.8     231102
GAS CONCEN PCT        0.0112      0.0456      2.2805       0.0012      0.0020      231102
EMISSION INDEX         4.80        39.2       3078.           1.6         2.8      231102
FUEL-AIR RATIO        0.0114                                                       231102
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ENGINE TEST DATA
DATE
08/11/76                 DATA POINT            TEST CELL                    236702
INSTRUMENT OPERATOR      236702                13                           236702
ERHARDT                                        TEST OPERATOR                236702
ENGINE MANUFACTURER                            TREMBLEY                     236702
LYCOMING                 MODEL                 SERIAL NUMBER                236702
FUEL IDENT.              ALF-502               LF02                         236702
JET-A HC RATIO 0.161     FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH       236702
BELLMOUTH AIR FLOW LB/SEC 2568.                231.1                        236702
233.0                    CORE AIRFLOW LB/SEC   FUEL-AIR RATIO MEAS.         236702
PT3 PSIA                 34.1                  0.0210                       236702
155.4                    TT3 DEG. RANKINE                                   236702
PT9 PSIA                1154.2                                              236702
18.473                   TT9 DEG RANKINE       EPR                          236702
NET THRUST LBS           1611.4                10.60                        236702
6133.0                   N1 RPM                N2 RPM                       236702
ACTUAL INLET PRESSURE PO PSIA 19370.           6253.                        236702
14.709                                                                      236702
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                    236702
530.4                                                                       236702
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         236702
116.5                                                                       236702
FILTER AREA .385 SI                                                         236702
CLEAN CK SMOKE NUMBER 0                                                     236702
SMOKE NUMBER          VOL.-LITERS    FLOW-CFM  PRESS.-PSIA  TEMP. DEG.FAH   236702
      18.7                   3.0         0.53       13.324           84.0   236702
      27.6                   4.0         0.53       13.374           83.0   236702
      33.9                   7.0         0.53       13.422           83.0   236702
      39.7                  11.0         0.52       13.373           84.0   236702
GASEOUS EMISSIONS                                                           236702
                     FID        NDIR       NDIR       CHEMI      CHEMI      236702
                     UHC         CO         CO2        NO         NOX       236702
RANGE                 1          1          2          3          3         236702
INSTR GAS TEMP      153.        54.        54.        62.        62.        236702
RAW VALUE MV          5.1      116.1      914.1      400.3      426.7       236702
GAS CONCEN PPM(C)     1.5        9.9    45105.3      102.6      109.5       236702
GAS CONCEN PCT      0.0002     0.0010     4.5105     0.0103     0.0109      236702
EMISSION INDEX      0.03        0.4      3154.         7.5        8.0       236702
FUEL-AIR RATIO      0.0222                                                  236702
                                                                            236702
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ENGINE TEST DATA                                                                238602
DATE                         DATA POINT             TEST CELL                   238602
08/11/76                     238602                 13                          238602
INSTRUMENT OPERATOR                                 TEST OPERATOR               238602
ERHARDT                                             TREMBLEY                    238602
ENGINE MANUFACTURER          MODEL                  SERIAL NUMBER               238602
LYCOMING                     ALF-502                LF02                        238602
FUEL IDENT.                  FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH      238602
JET-A HC RATIO 0.161         2288.                  239.4                       238602
BELLMOUTH AIR FLOW LB/SEC    CORE AIRFLOW LB/SEC    FUEL-AIR RATIO MEAS.        238602
225.1                        32.7                   0.0195                      238602
PT3 PSIA                     TT3 DEG. RANKINE                                   238602
145.3                       1131.3                                              238602
PT9 PSIA                     TT9 DEG RANKINE        EPR                         238602
17.929                       1559.2                   5.89                      238602
NET THRUST LBS               N1 RPM                 N2 RPM                      238602
5580.0                        19076.                6014.                       238602
ACTUAL INLET PRESSURE PO PSIA                                                   238602
14.721                                                                          238602
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                        238602
530.8                                                                           238602
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             238602
116.4                                                                           238602
FILTER AREA .385 SI                                                             238602
CLEAN CK SMOKE NUMBER 0                                                         238602
SMOKE NUMBER      VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          238602
        22.4              3.0          0.52      13.323            87.0         238602
        24.1              4.0          0.53      13.373            87.0         238602
        33.9              7.0          0.53      13.422            86.0         238602
        42.4             11.0          0.52      13.373            87.0         238602
GASEOUS EMISSIONS                                                               238602
                  FID         NDIR        NDIR         CHEMI       CHEMI        238602
                  UHC          CO          CO2          NO          NOX         238602
RANGE              1           1           2            2           2           238602
INSTR GAS TEMP   153.         53.         53.          62.         62.          238602
RAW VALUE MV       3.7         86.2       866.0        849.4       915.4        238602
GAS CONCEN PPM(C)    0.5          7.3      42074.4         91.8        99.0     238602
GAS CONCEN PCT   0.0001      0.0007      4.2074       0.0092      0.0099        238602
EMISSION INDEX     0.01         0.4       3154.           7.2         7.8       238602
FUEL-AIR RATIO   0.0207                                                         238602
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ENGINE TEST DATA
DATE                                                                    237502
08/11/76                      DATA POINT              TEST CELL         237502
INSTRUMENT OPERATOR           237502                  13                237502
ERHARDT                                               TEST OPERATOR     237502
ENGINE MANUFACTURER                                   TREMBLEY          237502
LYCOMING                      MODEL                   SERIAL NUMBER     237502
FUEL IDENT.                   ALF-502                 LF02              237502
JET-A HC RATIO 0.161          FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH 237502
BELLMOUTH AIR FLOW LB/SEC     1275.                   236.1             237502
174.7                         CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.  237502
PT3 PSIA                      24.8                    0.0143            237502
101.9                         TT3 DEG. RANKINE                          237502
PT9 PSIA                     1009.6                                     237502
16.251                        TT9 DEG RANKINE         EPR               237502
NET THRUST LBS                1347.6                   6.91             237502
3168.0                        N1 RPM                  N2 RPM            237502
                              17248.                  4729.             237502
ACTUAL INLET PRESSURE PO PSIA                                           237502
14.752                                                                  237502
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                237502
530.7                                                                   237502
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                     237502
112.6                                                                   237502
FILTER AREA .385 SI                                                     237502
CLEAN CK SMOKE NUMBER 0                                                 237502
SMOKE NUMBER          VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH 237502
        12.9                 3.0         0.52      11.799          85.0 237502
        14.9                 4.0         0.53      11.897          85.0 237502
        24.1                 7.0         0.52      11.897          85.0 237502
        30.8                11.0         0.52      11.848          84.0 237502
GASEOUS EMISSIONS                                                       237502
                    FID        NDIR        NDIR        CHEMI      CHEMI 237502
                    UHC        CO          CO2         NO         NOX   237502
RANGE                1          1           2          2          2     237502
INSTR GAS TEMP      153.       54.         54.        62.        62.    237502
RAW VALUE MV          4.8     341.5       639.7      468.7      514.0   237502
GAS CONCEN PPM(C)     1.3      31.8     29399.4       50.8       55.8   237502
GAS CONCEN PCT      0.0001    0.0032     2.9399     0.0051     0.0056   237502
EMISSION INDEX        0.04      2.2      3151.         5.7        6.2   237502
FUEL-AIR RATIO      0.0144                                              237502
                                                                        237502
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ENGINE TEST DATA                                                                 234402
DATE                          DATA POINT                 TEST CELL               234402
08/11/76                      234402                     13                      234402
INSTRUMENT OPERATOR                                      TEST OPERATOR           234402
ERHARDT                                                  TREMBLEY                234402
ENGINE MANUFACTURER           MODEL                      SERIAL NUMBER           234402
LYCOMING                      ALF-502                    LF02                    234402
FUEL IDENT.                   FUEL FLOW PPH              MANIFOLD FUEL TEMP FAH  234402
JET-A HC RATIO 0.161          1103.                      230.1                   234402
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC        FUEL-AIR RATIO MEAS.    234402
161.8                         23.0                       0.0133                  234402
PT3 PSIA                      TT3 DEG. RANKINE                                   234402
 92.4                          980.8                                             234402
PT9 PSIA                      TT9 DEG RANKINE            EPR                     234402
16.016                        1299.4                      6.27                   234402
NET THRUST LBS                N1 RPM                     N2 RPM                  234402
2705.0                        16798.                     4381.                   234402
ACTUAL INLET PRESSURE PO PSIA                                                    234402
14.752                                                                           234402
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                         234402
530.0                                                                            234402
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                              234402
113.0                                                                            234402
FILTER AREA .385 SI                                                              234402
CLEAN CK SMOKE NUMBER 0                                                          234402
SMOKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH         234402
      10.9                 3.0          0.52      11.799            83.0         234402
      14.9                 4.0          0.52      11.897            83.0         234402
      20.6                 7.0          0.52      11.848            83.0         234402
      29.2                11.0          0.52      11.848            83.0         234402
GASEOUS EMISSIONS                                                                234402
                    FID        NDIR        NDIR        CHEMI       CHEMI         234402
                    UHC        CO          CO2         NO          NOX           234402
RANGE                1          1           2           2           2            234402
INSTR GAS TEMP      153.       54.         54.         62.         62.           234402
RAW VALUE MV          5.6      539.5       596.6       402.7       457.5         234402
GAS CONCEN PPM(C)     1.9        53.0      27120.2         43.7        49.6      234402
GAS CONCEN PCT      0.0002     0.0053      2.7120      0.0044      0.0050        234402
EMISSION INDEX        0.07       3.9       3148.          5.3         6.0        234402
FUEL-AIR RATIO      0.0123                                                       234402
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ENGINE TEST DATA                                                                    233302
DATE                         DATA POINT              TEST CELL                      233302
08/11/76                     233302                  13                             233302
INSTRUMENT OPERATOR                                  TEST OPERATOR                  233302
ERHARDT                                              TREMBLEY                       233302
ENGINE MANUFACTURER          MODEL                   SERIAL NUMBER                  233302
LYCOMING                     ALF-502                 LF02                           233302
FUEL IDENT.                  FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH         233302
JET-A HC RATIO 0.161          774.                   215.6                          233302
BELLMOUTH AIR FLOW LB/SEC    CORE AIRFLOW LB/SEC     FUEL-AIR RATIO MEAS.           233302
131.1                        19.0                    0.0113                         233302
PT3 PSIA                     TT3 DEG. RANKINE                                       233302
 72.5                         911.1                                                 233302
PT9 PSIA                     TT5 DEG RANKINE         EPR                            233302
15.549                       1205.4                   4.91                          233302
NET THRUST LBS               N1 RPM                  N2 RPM                         233302
1770.0                       15512.                  3597.                          233302
ACTUAL INLET PRESSURE PO PSIA                                                       233302
14.760                                                                              233302
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                            233302
530.0                                                                               233302
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 233302
112.5                                                                               233302
FILTER AREA .385 SI                                                                 233302
CLEAN CK SMOKE NUMBER 0                                                             233302
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM PRESS.-PSIA   TEMP. DEG.FAH             233302
        6.7                3.0         0.50     11.845              83.0            233302
        6.7                4.0         0.50     11.845              82.0            233302
       10.9                7.0         0.53     11.796              83.0            233302
       16.8               11.0         0.52     11.845              83.0            233302
GASEOUS EMISSIONS                                                                   233302
                    FID       NDIR      NDIR       CHEMI     CHEMI                  233302
                    UHC       CO        CO2        NO        NOX                    233302
RANGE                1        2          2         2         2                      233302
INSTR GAS TEMP      153.      52.       53.        62.       62.                    233302
RAW VALUE MV         18.0    301.6     513.8      262.7     336.4                   233302
GAS CONCEN PPM(C)     11.1    126.8    22864.2      28.5      36.5                  233302
GAS CONCEN PCT      0.0011   0.0127    2.2864     0.0028    0.0036                  233302
EMISSION INDEX       0.48     11.1     3136.        4.1       5.2                   233302
FUEL-AIR RATIO      0.0112                                                          233302
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ENGINE TEST DATA                                                                232202
DATE                          DATA PCINT          TEST CELL                     232202
C8/11/76                      232202              13                            232202
INSTRUMENT OPERATOR                               TEST CPERATOR                 232202
ERHARDT                                           TREMBLEY                      232202
ENGINE MANUFACTURER           MCDEL               SERIAL NUMBER                 232202
LYCOMING                      ALF-502             LF02                          232202
FUEL IDENT.                   FUEL FLCW PPH       MANIFCLD FUEL TEMP FAH        232202
JET-A HC RATIO 0.161           442.               187.8                         232202
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLCW LB/SEC FUEL-AIR RATIO MEAS.          232202
 78.7                         11.4                0.0107                        232202
PT3 PSIA                      TT3 DEG. RANKINE                                  232202
 39.9                          750.2                                            232202
PT9 PSIA                      TT9 DEG RANKINE     EPR                           232202
15.054                        1221.1               2.70                         232202
NET THRUST LBS                N1 RPM              N2 RPM                        232202
 595.0                        12170.              2178.                         232202
ACTUAL INLET PRESSURE PC PSIA                                                   232202
14.777                                                                          232202
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                        232202
530.0                                                                           232202
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             232202
114.8                                                                           232202
FILTER AREA .385 SI                                                             232202
CLEAN CK SMCKE NUMBER 0                                                         232202
SMOKE NUMBER           VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH      232202
         2.3                   3.0          0.52    11.795             82.0     232202
         2.3                   4.0          0.52    11.795             83.0     232202
         4.5                   7.0          0.53    11.746             82.0     232202
         4.5                  11.0          0.50    11.819             81.0     232202
GASECUS EMISSICNS                                                               232202
                   FID         NDIR        NDIR        CHEMI       CHEMI        232202
                   UHC         CC          CO2         NO          NCX          232202
RANGE               1           2           2           1           1           232202
INSTR GAS TEMP     153.        52.         52.         62.         62.          232202
RAW VALUE MV       103.8       763.2       506.1       535.5       861.7        232202
GAS CCNCEN PPM(C)    74.6       379.5       22477.1        13.9        22.1     232202
GAS CCNCEN PCT     C.CC75      0.0379      2.2477      0.0014      0.C022       232202
EMISSION INCEX      3.25        33.2       3092.          2.0         3.2       232202
FUEL-AIR RATIO     0.0112                                                       232202
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ENGINE TEST DATA                                                                  231112
DATE                            DATA POINT          TEST CELL                     231112
08/11/76                        231112              13                            231112
INSTRUMENT OPERATOR                                 TEST OPERATOR                 231112
ERHARDT                                             TREMBLEY                      231112
ENGINE MANUFACTURER             MODEL               SERIAL NUMBER                 231112
LYCOMING                        ALF-502             LF02                          231112
FUEL IDENT.                     FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH        231112
JET-A HC RATIO 0.161             381.               169.5                         231112
BELLMOUTH AIR FLOW LB/SEC       CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.          231112
 67.2                             9.5               0.0111                        231112
PT3 PSIA                        TT3 DEG. RANKINE                                  231112
 33.6                            707.2                                            231112
PT9 PSIA                        TT9 DEG RANKINE     EPR                           231112
14.982                          1236.9               2.27                         231112
NET THRUST LBS                  N1 RPM              N2 RPM                        231112
 400.0                          10888.              1860.                         231112
ACTUAL INLET PRESSURE FC PSIA                                                     231112
14.785                                                                            231112
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                          231112
530.1                                                                             231112
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                               231112
113.5                                                                             231112
FILTER AREA .385 SI                                                               231112
CLEAN CK SMOKE NUMBER 0                                                           231112
SMOKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          231112
        2.3                 3.0           0.50      11.354             83.0       231112
        2.3                 4.0           0.53      11.305             82.0       231112
        2.3                 7.0           0.53      11.354             83.0       231112
        2.3                11.0           0.52      11.305             83.0       231112
GASEOUS EMISSIONS                                                                 231112
                    FID         NDIR        NDIR        CHEMI      CHEMI          231112
                    UHC          CO          CO2         NO         NOX           231112
RANGE                1           2           2           1          1             231112
INSTR GAS TEMP      153.        51.         51.         62.        62.            231112
RAW VALUE MV        155.7       911.0       509.9       436.9      784.0          231112
GAS CONCEN PPM(C)    113.0       463.2       22670.6       11.4       20.1        231112
GAS CONCEN PCT      0.0113      0.0463      2.2671      0.0011     0.0020         231112
EMISSION INDEX       4.86        40.0       3076.          1.6        2.8         231112
FUEL-AIR RATIO      0.0113                                                        231112
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ENGINE TEST CATA                                                                        241103
CATE                          CATA PCINT           TEST CELL                            241103
C8/12/76                      241103               13                                   241103
INSTRUMENT CPERATOR                                TEST OPERATOR                        241103
ERHARDT                                            TREMBLEY                             241103
ENGINE MANUFACTURER           MODEL                SERIAL NUMBER                        241103
LYCCMING                      ALF-502              LF02                                 241103
FUEL IDENT.                   FUEL FLCW PPH        MANIFOLD FUEL TEMP FAH               241103
JET-A HC RATIO 0.161           38C.                183.2                                241103
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLOW LB/SEC  FLEL-AIR RATIO MEAS.                 241103
 66.9                          9.5                 0.0111                               241103
PT3 PSIA                      TT3 DEG. RANKINE                                          241103
 33.6                          718.2                                                    241103
PT9 PSIA                      TT9 CEG RANKINE      EPR                                  241103
14.909                        1261.9                2.28                                241103
NET THRLST LBS                N1 RPM               N2 RPM                               241103
 399.0                        10994.               1861.                                241103
ACTUAL INLET PRESSURE PO PSIA                                                           241103
14.7C8                                                                                  241103
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                                241103
538.2                                                                                   241103
SPECIFIC HLMIDITY GRAINS/LB CRY AIR                                                     241103
107.2                                                                                   241103
FILTER AREA .385 SI                                                                     241103
CLEAN CK SMCKE NUMBER 0                                                                 241103
SMOKE NUMEER          VOL.-LITERS       FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH             241103
            0.0               3.0             0.52    11.081             87.0           241103
            0.0               4.C             C.52    11.081             87.0           241103
            2.3               7.0             0.52    11.130             87.0           241103
            2.3              11.0             0.53    11.13C             87.0           241103
GASEOUS EMISSICNS                                                                       241103
                      FID        NDIR        NDIR        CHEMI       CHEMI              241103
                      UHC         CC          CC2         NO          NOX               241103
RANGE                  1          2           2           1           1                 241103
INSTR GAS TEMP        153.       54.         54.         62.         62.                241103
RAW VALUE MV          188.6      969.3       518.6       457.5       783.1              241103
GAS CCNCEN PPM(C)      139.3      506.4     23039.2        11.6        19.9             241103
GAS CCNCEN PCT        C.0139     C.C5C6      2.3039      0.C012      0.C020             241103
EMISSION INDEX         5.E8       42.9       3069.          1.6         2.8             241103
FUEL-AIR RATIO        C.0115                                                            241103
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ENGINE TEST CATA                                                             246703
CATE                           DATA POINT            TEST CELL               246703
C8/12/76                       246703                13                      246703
INSTRUMENT CPERATOR                                  TEST OPERATOR           246703
ERHARCT                                              TREMBLEY                246703
ENGINE MANUFACTURER            MODEL                 SERIAL NUMBER           246703
LYCCMING                       ALF-502               LF02                    246703
FUEL ICENT.                    FUEL FLOW PPH         MANIFCLD FUEL TEMP FAH  246703
JET-A HC RATIO 0.161           2464.                 230.9                   246703
BELLMCUTH AIR FLOW LB/SEC      CORE AIRFLCW LB/SEC   FUEL-AIR RATIO MEAS.    246703
228.1                          33.2                  0.0206                  246703
PT3 PSIA                       TT3 DEG. RANKINE                              246703
151.3                         1153.0                                         246703
PT9 PSIA                       TT9 DEG RANKINE       EPR                     246703
18.170                         16C6.5                10.40                   246703
NET THRUST LBS                 N1 RPM                N2 RPM                  246703
5858 0                         193C6.                6185.                   246703
ACTUAL INLET PRESSURE FO PSIA                                                246703
14.626                                                                       246703
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                     246703
535.2                                                                        246703
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                          246703
105.2                                                                        246703
FILTER AREA .385 SI                                                          246703
CLEAN CK SMCKE NUMBER 0                                                      246703
SMCKE NUMBER        VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH      246703
       18.7                 3.0         0.53     11.227           87.0       246703
       24.1                 4.0         C.53     11.227           87.0       246703
       25.9                 7.0         0.53     11.227           87.0       246703
       35.4                11.0         C.54     11.276           87.0       246703
GASEOUS EMISSIONS                                                            246703
                  FID        NDIR        NCIR        CHEMI      CHEMI        246703
                  UHC         CC          CC2         NC         NOX         246703
RANGE              1          1           2           3          3           246703
INSTR GAS TEMP    153.       54.         54.         62.        62.          246703
RAW VALLE MV        3.1     117.0        9C4.5       392.3      423.8        246703
GAS CCNCEN PPM(C)   0.2        8.4     44701.6       101.6      109.8        246703
GAS CCNCEN PCT    C.0CC0     C.0CC8      4.4702     0.0102     0.0110        246703
EMISSION INCEX    0.0C        C.4      3154.           7.5        8.1        246703
FUEL-AIR RATIO    C.0220                                                     2467C3
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ENGINE TEST DATA
DATE                                                                              248603
08/12/76                      DATA POINT               TEST CELL                  248603
INSTRUMENT OPERATOR           248603                   13                         248603
ERHARDT                                                TEST OPERATOR              248603
ENGINE MANUFACTURER           MODEL                    TREMBLEY                   248603
LYCOMING                      ALF-502                  SERIAL NUMBER              248603
FUEL IDENT.                   FUEL FLOW PPH            LF02                       248603
JET-A HC RATIO 0.161          2208.                    MANIFOLD FUEL TEMP FAH     248603
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC      245.8                      248603
220.0                         31.5                     FUEL-AIR RATIO MEAS.       248603
PT3 PSIA                                               0.0195                     248603
141.2                         TT3 DEG. RANKINE                                    248603
PT9 PSIA                     1131.0                                               248603
17.706                        TT9 DEG RANKINE          EPR                        248603
NET THRUST LBS                1561.1                    9.66                      248603
5314.0                        N1 RPM                   N2 RPM                     248603
ACTUAL INLET PRESSURE P0 PSIA 19014.                   5928.                      248603
14.628                                                                            248603
ACTUAL INLET TEMPERATURE T0 DEG. RANKINE                                          248603
535.5                                                                             248603
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                               248603
104.0                                                                             248603
FILTER AREA .385 SI                                                               248603
CLEAN CK SMOKE NUMBER 0                                                           248603
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH           248603
        18.7                3.0         0.52       11.226            87.0         248603
        20.6                4.0         0.53       11.226            87.0         248603
        29.2                7.0         0.53       11.275            87.0         248603
        36.9               11.0         0.53       11.226            87.0         248603
GASEOUS EMISSIONS                                                                 248603
                    FID          NDIR         NDIR         CHEMI        CHEMI     248603
                    UHC          CO           CO2          NO           NOX       248603
RANGE               1            1            2            2            2         248603
INSTR GAS TEMP      153.         54.          54.          62.          62.       248603
RAW VALUE MV          2.3          95.8       853.2        826.8        888.1     248603
GAS CONCEN PPM(C)    -0.4           6.6     41467.8         90.9         97.7     248603
GAS CONCEN PCT      -.0000       0.0007       4.1468       0.0091       0.0098    248603
EMISSION INDEX      -0.01          0.3      3154.            7.2          7.8     248603
FUEL-AIR RATIO      0.0204                                                        248603
                                                                                  248603
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ENGINE TEST CATA                                                                            247503
CATE                         CATA PCINT             TEST CELL                               247503
C8/12/76                     247503                 13                                      247503
INSTRUMENT OPERATOR                                 TEST OPERATOR                           247503
ERHARDT                                             TREMBLEY                                247503
ENGINE MANUFACTURER          MCDEL                  SERIAL NUMBER                           247503
LYCCMING                     ALF-502                LF02                                    247503
FUEL IDENT.                  FUEL FLCW PPH          MANIFCLD FUEL TEMP FAH                  247503
JET-A HC RATIO 0.161         1255.                  244.2                                   247503
BELLMCUTH AIR FLCW LB/SEC    CCRE AIRFLCW LB/SEC    FUEL-AIR RATIO MEAS.                    247503
170.2                          24.4                 0.0143                                  247503
PT3 PSIA                      TT3 DEG. RANKINE                                              247503
100.1                       1015.0                                                          247503
PT9 PSIA                      TT9 DEG RANKINE       EPR                                     247503
16.137                        1357.9                 6.83                                   247503
NET THRLST LBS                N1 RFM                N2 RPM                                  247503
3C86.C                        17284.                4715.                                   247503
ACTUAL INLET PRESSURE PO PSIA                                                               247503
14.668                                                                                      247503
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                                    247503
536.0                                                                                       247503
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                         247503
105.6                                                                                       2475C3
FILTER AREA .385 SI                                                                         247503
CLEAN CK SMCKE NUMBER 0                                                                     247503
SMOKE NUMBER         VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH                    247503
       12.9                  3.0          C.52       11.C78              86.0               247503
       12.9                  4.0          0.52       11.C78              86.0               247503
       16.8                  7.C          C.53       11.127              86.0               247503
       25.9                 11.C          0.53       11.127              86.0               247503
GASEOLS EMISSICNS                                                                           2475C3
                     FIC         NDIR         NDIR         CHEMI        CHEMI               247503
                     UHC          CC           CC2          NO           NOX                247503
RANGE                 1            1            2            2            2                 247503
INSTR GAS TEMP       153.         53.          53.          62.          62.                247503
RAW VALLE MV           3.1       352.8        638.8        468.1        517.3               247503
GAS CCNCEN PPM(C)      0.2        31.5       29377.0         51.4         56.8              247503
GAS CONCEN PCT       C.CCC0      C.CC31       2.9377       0.CC51       0.0057              247503
EMISSICN INCEX         0.01        2.1       3151.           5.8          6.4               247503
FUEL-AIR RATIO       C.0144                                                                 247503
                                                                                            247503
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ENGINE TEST CATA
CATE                                                                    244403
C8/12/76                     CATA PCINT                               244403
INSTRUMENT OPERATOR          244403              TEST CELL            244403
ERHARDT                                          13                   244403
ENGINE MANUFACTURER                              TEST OPERATOR        244403
LYCOMING                     MODEL               TREMBLEY             244403
FUEL IDENT.                  ALF-502             SERIAL NUMBER        244403
JET-A HC RATIO 0.161         FUEL FLCW PPH       LF02                 244403
BELLMCUTH AIR FLCW LB/SEC    1060.               MANIFOLC FUEL TEMP FAH 244403
155.5                        CORE AIRFLOW LB/SEC 235.2                244403
PT3 PSIA                     22.5                FUEL-AIR RATIO MEAS. 244403
 89.7                        TT3 DEG. RANKINE    0.0131               244403
PT9 PSIA                     982.6                                    244403
15.885                       TT9 DEG RANKINE     EPR                  244403
NET THRLST LBS               1305.6               6.12                244403
2557.0                       N1 RPM              N2 RPM               244403
ACTUAL INLET PRESSURE PO PSIA 16760.             4331.                244403
14.670                                                                244403
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                              244403
535.9                                                                 244403
SPECIFIC HLMIDITY GRAINS/LB CRY AIR                                   244403
106.0                                                                 244403
FILTER AREA .385 SI                                                   244403
CLEAN CK SMCKE NUMBER 0                                               244403
SMOKE NUMBER       VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH 244403
        10.9              3.0          0.52      11.179          86.0  244403
        10.9              4.0          0.53      11.228          86.0  244403
        16.8              7.0          0.53      11.228          86.0  244403
        24.1             11.0          0.54      11.228          86.0  244403
GASEOUS EMISSIONS                                                      244403
                   FID        NDIR       NDIR       CHEMI      CHEMI   244403
                   UHC        CC         CO2        NO         NOX     244403
RANGE               1          1          2          2          2      244403
INSTR GAS TEMP     154.       53.        53.        62.        62.     244403
RAW VALUE MV         3.9      569.7      591.7      397.9      454.4   244403
GAS CCNCEN PPM(C)      0.8       54.6     26891.5       43.6       49.8 244403
GAS CCNCEN PCT     0.0001     0.0055     2.6892     0.0044     0.0050  244403
EMISSION INDEX      0.03         4.1     3148.         5.3        6.1  244403
FUEL-AIR RATIO     0.0131                                              244403
                                                                       244403
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ENGINE TEST CATA                                                                       243303
CATE                          DATA PCINT          TEST CELL                            243303
C8/12/76                      243303              13                                   243303
INSTRUMENT CPERATOR                               TEST OPERATOR                        243303
ERHARDT                                           TREMBLEY                             243303
ENGINE MANUFACTURER           MODEL               SERIAL NUMBER                        243303
LYCCMING                      ALF-502             LF02                                 243303
FUEL IDENT.                   FUEL FLOW PPH       MANIFOLC FUEL TEMP FAH               243303
JET-A HC RATIC C.161            753.              218.4                                243303
BELLMCUTH AIR FLCW LB/SEC     CCRE AIRFLCW LB/SEC FUEL-AIR RATIO MEAS.                 243303
129.7                         18.7                0.0112                               243303
PT3 PSIA                      TT3 DEG. RANKINE                                         243303
 71.0                          914.0                                                   243303
PT9 PSIA                      TT9 DEG RANKINE     EPR                                  243303
15.447                        1212.5               4.84                                243303
NET THRUST LBS                N1 RPM              N2 RPM                               243303
17C7.0                        1549C.              3569.                                243303
ACTUAL INLET PRESSURF FC PSIA                                                          243303
14.686                                                                                 243303
ACTUAL INLET TEMPERATURE TO CEG. RANKINE                                               243303
534.7                                                                                  243303
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                    243303
110.8                                                                                  243303
FILTER AREA .385 SI                                                                    243303
CLEAN CK SMCKE NLMBER 0                                                                243303
SMOKE NUMBER          VCL.-LITERS     FLCW-CFM PRESS.-PSIA   TEMP. DEG.FAH             243303
        6.7                   3.0          0.52     11.080            85.0             243303
        6.7                   4.0          C.53     11.179            85.0             243303
       10.9                   7.C          C.53     11.179            85.0             243303
       14.9                  11.0          0.53     11.129            85.0             243303
GASEOUS EMISSICNS                                                                      243303
                    FID          NDIR         NCIR         CHEMI        CHEMI          243303
                    LHC          CO           CC2          NO           NOX            243303
RANGE                1           2            2            2            2              243303
INSTR GAS TEMP      153.         53.          53.          62.          62.            243303
RAW VALLE MV         18.7        313.2        5C8.7        256.2        333.8          243303
GAS CCNCEN PPM(C)      12.9        130.1       22738.C        28.C         36.5        243303
GAS CCNCEN PCT      C.0013       0.0130       2.2738       C.C028       0.C036         243303
EMISSICN INCEX        0.56         11.4       3135.          4.0          5.3          243303
FUEL-AIF RATIC      C.0111                                                             243303
                                                                                       243303
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ENGINE TEST DATA
DATE
08/12/76                      DATA POINT            TEST CELL                 242203
INSTRUMENT OPERATOR           242203                13                        242203
ERHARDT                                             TEST OPERATOR             242203
ENGINE MANUFACTURER                                 TREMBLEY                  242203
LYCOMING                      MODEL                 SERIAL NUMBER             242203
FUEL IDENT.                   ALF-502               LF02                      242203
JET-A HC RATIO 0.161          FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH    242203
BELLMOUTH AIR FLOW LB/SEC      453.                 190.7                     242203
 81.0                         CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.        242203
PT3 PSIA                      11.7                  0.0108                    242203
 41.0                         TT3 DEG. RANKINE                                242203
PT9 PSIA                       764.4                                          242203
14.991                        TT9 DEG RANKINE       EPR                       242203
NET THRUST LBS                1228.3                 2.79                     242203
 631.0                        N1 RPM                N2 RPM                    242203
ACTUAL INLET PRESSURE PO PSIA 12458.                2225.                     242203
14.704                                                                        242203
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                      242203
534.9                                                                         242203
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           242203
111.4                                                                         242203
FILTER AREA .385 SI                                                           242203
CLEAN CK SMOKE NUMBER 0                                                       242203
SMOKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH      242203
      0.0                 3.0          0.52      11.079                       242203
      0.0                 4.0          0.52      11.128           85.0        242203
      4.5                 7.0          0.52      11.079           85.0        242203
      2.3                11.0          0.50      11.079           85.0        242203
GASEOUS EMISSIONS                                                 85.0        242203
                   FID         NDIR        NDIR        CHEMI                  242203
                   UHC         CO          CO2         NO          CHEMI      242203
RANGE              1           2           2           1           NOX        242203
INSTR GAS TEMP     153.        53.         53.         62.         1          242203
RAW VALUE MV        87.8       720.5       504.2       544.8       62.        242203
GAS CONCEN PPM(C)    64.6       353.7       22509.6                888.0      242203
GAS CONCEN PCT     0.0065      0.0354      2.2510         14.0        22.7    242203
EMISSION INDEX      2.82        31.0       3097.       0.0014      0.0023     242203
FUEL-AIR RATIO     0.0112                                 2.0         3.3     242203
                                                                              242203
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ENGINE TEST CATA                                                                      241113
CATE                          CATA POINT          TEST CELL                           241113
C8/12/76                      241113              13                                  241113
INSTRUMENT CPERATOR                               TEST OPERATOR                       241113
ERHARDT                                           TREMBLEY                            241113
ENGINE MANUFACTLRER           MCDEL               SERIAL NUMBER                       241113
LYCCMING                      ALF-502             LF02                                241113
FUEL IDENT.                   FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH              241113
JET-A HC RATIO C.161           373.               175.5                               241113
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLCW LB/SEC FUEL-AIR RATIO MEAS.                241113
 64.5                          9.2                0.0113                              241113
PT3 PSIA                      TT3 DEG. RANKINE                                        241113
 32.5                          7C7.8                                                  241113
PT9 PSIA                      TT9 DEG RANKINE     EPR                                 241113
14.890                        1261.3               2.21                               241113
NET THRLST LBS                N1 RPM              N2 RPM                              241113
 389.0                        1C728.              1784.                               241113
ACTUAL INLET PRESSURE PO PSIA                                                         241113
14.702                                                                                241113
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                              241113
535.4                                                                                 241113
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                   241113
1C6.8                                                                                 241113
FILTER AREA .385 SI                                                                   241113
CLEAN CK SMCKE NUMBER 0                                                               241113
SMOKE NUMBER        VOL.-LITERS      FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH              241113
        0.0                 3.0          0.52     11.C75             86.0             241113
        0.C                 4.0          C.52     11.C75             86.0             241113
        0.0                 7.0          0.52     11.075             86.0             241113
        2.3                11.0          C.52     11.C75             86.0             241113
GASECUS EMISSIONS                                                                     241113
                    FID         NDIR        NDIR        CHEMI        CHEMI            241113
                    UHC          CC          CO2         NO           NOX             241113
RANGE                1           2           2           1            1               241113
INSTR GAS TEMP      153.        52.         52.         62.          62.              241113
RAW VALUE MV        149.3       919.4       515.3       436.8        738.4            241113
GAS CCNCEN PPM(C)    110.7       466.5       23C73.6       11.3         20.2          241113
GAS CCNCEN PCT      C.0111      C.C466      2.3074      0.C011       0.C020           241113
EMISSICN INDEX       4.68        39.6       3078.          1.6          2.8           241113
FUEL-AIR RATIO      C.C115                                                            241113
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ENGINE TEST DATA                                                      251104
DATE                       DATA POINT           TEST CELL             251104
08/13/76                   251104               13                    251104
INSTRUMENT OPERATOR                             TEST OPERATOR         251104
ERHARDT                                         TREMBLEY              251104
ENGINE MANUFACTURER        MODEL                SERIAL NUMBER         251104
LYCOMING                   ALF-502              LF02                  251104
FUEL IDENT.                FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH 251104
JET-A HC RATIO 0.161        362.                175.4                 251104
BELLMOUTH AIR FLOW LB/SEC  CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.  251104
 66.6                        9.6                0.0105                251104
PT3 PSIA                   TT3 DEG. RANKINE                           251104
 33.8                       725.3                                     251104
PT9 PSIA                   TT9 DEG RANKINE      EPR                   251104
14.819                     1211.8                2.31                 251104
NET THRUST LBS             N1 RPM               N2 RPM                251104
 397.0                     11208.               1866.                 251104
ACTUAL INLET PRESSURE PO PSIA                                         251104
14.621                                                                251104
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                              251104
539.9                                                                 251104
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                   251104
122.7                                                                 251104
FILTER AREA .385 SI                                                   251104
CLEAN CK SMOKE NUMBER 0                                               251104
SMOKE NUMBER       VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH 251104
        0.0                 3.0        0.52    11.039            88.0 251104
        2.3                 4.0        0.52    11.039            88.0 251104
        2.3                 7.0        0.53    11.089            88.0 251104
        2.3                11.0        0.52    11.089            88.0 251104
GASEOUS EMISSIONS                                                     251104
                   FID         NDIR       NDIR       CHEMI      CHEMI 251104
                   UHC          CO         CO2        NO         NOX  251104
RANGE               2           2          2          1          1    251104
INSTR GAS TEMP     153.        55.        55.        62.        62.   251104
RAW VALUE MV        17.3       895.9      468.4      441.9      747.7 251104
GAS CONCEN PPM(C)   128.5       456.5      21159.9       11.2       18.9 251104
GAS CONCEN PCT     0.0129     0.0456     2.1160     0.0011     0.0019 251104
EMISSION INDEX      5.91        42.1      3070.         1.7        2.9 251104
FUEL-AIR RATIO     0.0106                                             251104
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ENGINE TEST DATA                                                                      256704
DATE                           DATA POINT           TEST CELL                         256704
08/13/76                       256704               13                                256704
INSTRUMENT OPERATOR                                 TEST OPERATOR                     256704
ERHARDT                                             TREMBLEY                          256704
ENGINE MANUFACTURER            MODEL                SERIAL NUMBER                     256704
LYCOMING                       ALF-502              LF02                              256704
FUEL IDENT.                    FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH            256704
JET-A HC RATIO 0.161           2497.                240.9                             256704
BELLMOUTH AIR FLOW LB/SEC      CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.              256704
228.3                          32.9                 0.0211                            256704
PT3 PSIA                       TT3 DEG. RANKINE                                       256704
151.8                         1163.6                                                  256704
PT9 PSIA                       TT9 DEG RANKINE      EPR                               256704
18.101                         1611.7               10.45                             256704
NET THRUST LBS                 N1 RPM               N2 RPM                            256704
5783.0                         19462.               6247.                             256704
ACTUAL INLET PRESSURE PO PSIA                                                         256704
14.540                                                                                256704
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                              256704
537.3                                                                                 256704
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                   256704
124.6                                                                                 256704
FILTER AREA .385 SI                                                                   256704
CLEAN CK SMOKE NUMBER 0                                                               256704
SMOKE NUMBER         VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              256704
        14.9                  3.0         0.52       11.139             90.0          256704
        18.7                  4.0         0.52       11.139             90.0          256704
        30.8                  7.0         0.53       11.187             89.0          256704
        36.9                 11.0         0.53       11.187             90.0          256704
GASEOUS EMISSIONS                                                                     256704
                     FID       NDIR       NDIR       CHEMI       CHEMI                256704
                     UHC        CO         CO2        NO          NOX                 256704
RANGE                 1         1          2          3           3                   256704
INSTR GAS TEMP       153.      54.        54.        62.         62.                  256704
RAW VALUE MV           7.2     112.1      883.0      387.6       412.5                256704
GAS CONCEN PPM(C)      3.8       8.5     44563.4       100.0       106.5              256704
GAS CONCEN PCT       0.0004    0.0008     4.4563     0.0100      0.0107               256704
EMISSION INDEX        0.08       0.4      3154.         7.4         7.9               256704
FUEL-AIR RATIO       0.0219                                                           256704
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ENGINE TEST DATA                                                          258604
DATE                          DATA POINT          TEST CELL               258604
08/13/76                      258604              13                      258604
INSTRUMENT OPERATOR                               TEST OPERATOR           258604
ERHARDT                                           TREMBLEY                258604
ENGINE MANUFACTURER           MODEL               SERIAL NUMBER           258604
LYCOMING                      ALF-502             LF02                    258604
FUEL IDENT.                   FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH  258604
JET-A HC RATIO 0.161          2213.               255.2                   258604
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.    258604
219.2                         31.3                0.0197                  258604
PT3 PSIA                      TT3 DEG. RANKINE                            258604
140.9                       1138.4                                        258604
PT9 PSIA                      TT9 DEG RANKINE     EPR                     258604
17.568                        1562.8               9.69                   258604
NET THRUST LBS                N1 RPM              N2 RPM                  258604
5267.0                        19144.              5979.                   258604
ACTUAL INLET PRESSURE PO PSIA                                             258604
14.543                                                                    258604
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                  258604
537.3                                                                     258604
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                       258604
123.8                                                                     258604
FILTER AREA .385 SI                                                       258604
CLEAN CK SMOKE NUMBER 0                                                   258604
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   258604
        16.8                3.0          0.52     11.139            89.0  258604
        22.4                4.0          0.52     11.139            88.0  258604
        29.2                7.0          0.53     11.089            88.0  258604
        39.7               11.0          0.53     11.089            88.0  258604
GASEOUS EMISSIONS                                                         258604
                    FID       NDIR      NDIR      CHEMI     CHEMI         258604
                    UHC       CO        CO2       NO        NOX           258604
RANGE                1         1         2         2         2            258604
INSTR GAS TEMP      153.      54.       54.       62.       62.           258604
RAW VALUE MV          5.7       89.1     838.1     814.0     878.6        258604
GAS CONCEN PPM(C)       2.6        6.5    41672.4      89.6      96.8     258604
GAS CONCEN PCT      0.0003    0.0006    4.1672    0.0090    0.0097        258604
EMISSION INDEX      0.06      0.3       3154.        7.1       7.7        258604
FUEL-AIR RATIO      0.0205                                                258604
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ENGINE TEST DATA
DATE                                                                                257504
08/13/76                      DATA POINT             TEST CELL                      257504
INSTRUMENT OPERATOR           257504                 13                             257504
ERHARDT                                              TEST OPERATOR                  257504
ENGINE MANUFACTURER                                  TREMBLEY                       257504
LYCOMING                      MODEL                  SERIAL NUMBER                  257504
FUEL IDENT.                   ALF-502                LF02                           257504
JET-A HC RATIO 0.161          FUEL FLOW PPH          MANIFOLD FUEL TEMP FAH         257504
BELLMOUTH AIR FLOW LB/SEC     1260.                  248.6                          257504
171.1                         CORE AIRFLOW LB/SEC    FUEL-AIR RATIO MEAS.           257504
PT3 PSIA                      24.3                   0.0144                         257504
100.2                         TT3 DEG. RANKINE                                      257504
PT9 PSIA                     1021.6                                                 257504
16.060                        TT9 DEG RANKINE        EPR                            257504
NET THRUST LBS                1356.8                  6.87                          257504
3045.0                        N1 RPM                 N2 RPM                         257504
ACTUAL INLET PRESSURE FC PSIA 17382.                 4727.                          257504
14.580                                                                              257504
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                            257504
537.7                                                                               257504
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 257504
123.0                                                                               257504
FILTER AREA .385 SI                                                                 257504
CLEAN CK SMOKE NUMBER 0                                                             257504
SMOKE NUMBER          VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH          257504
       10.9                   3.0           0.52      11.139                        257504
       12.9                   4.0           0.52      11.089              88.0      257504
       20.6                   7.0           0.52      11.089              88.0      257504
       29.2                  11.0           0.53      11.089              88.0      257504
GASEOUS EMISSIONS                                                         88.0      257504
                      FID          NDIR         NDIR          CHEMI                 257504
                      UHC          CO           CO2           NO           CHEMI    257504
RANGE                  1           1            2             2            NOX      257504
INSTR GAS TEMP        153.         53.          53.           62.          2        257504
RAW VALUE MV            6.5        344.9        623.9         463.5        62.      257504
GAS CONCEN PPM(C)         3.2        31.5         29343.8        50.9      513.1    257504
GAS CONCEN PCT        0.0003       0.0031       2.9344        0.0051         56.4   257504
EMISSION INDEX         0.11          2.2        3151.           5.7        0.0056   257504
FUEL-AIR RATIO        0.0144                                                 6.3    257504
                                                                                    257504
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ENGINE TEST CATA
DATE                         CATA POINT            TEST CELL                       254404
C8/13/76                     254404                13                              254404
INSTRUMENT OPERATCR                                TEST OPERATOR                   254404
ERHARDT                                            TREMBLEY                        254404
ENGINE MANUFACTURER          MODEL                 SERIAL NUMBER                   254404
LYCCMING                     ALF-502               LF02                            254404
FUEL IDENT.                  FUEL FLOW PPH         MANIFOLC FUEL TEMP FAH          254404
JET-A HC RATIO 0.161         1070.                 236.3                           254404
BELLMCUTH AIR FLCW LB/SEC    CORE AIRFLOW LB/SEC   FUEL-AIR RATIO MEAS.            254404
157.3                        22.7                  0.0131                          254404
PT3 PSIA                     TT3 DEG. RANKINE                                      254404
 90.6                         989.7                                                254404
PT9 PSIA                     TT9 DEG RANKINE       EFR                             254404
15.812                       1306.0                 6.21                           254404
NET THRUST LBS               N1 RPM                N2 RPM                          254404
2588.0                       16886.                4359.                           254404
ACTUAL INLET PRESSURE PO PSIA                                                      254404
14.589                                                                             254404
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                           254404
537.0                                                                              254404
SPECIFIC HLMIDITY GRAINS/LB DRY AIR                                                254404
123.8                                                                              254404
FILTER AREA .385 SI                                                                254404
CLEAN CK SMOKE NUMBER 0                                                            254404
SMOKE NUMBER        VOL.-LITERS        FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH         254404
        10.9                3.0              0.52     11.142          87.0         254404
        12.9                4.0              0.53     11.142          87.0         254404
        18.7                7.0              0.53     11.142          87.0         254404
        25.9               11.0              0.53     11.191          87.0         254404
GASEOUS EMISSIONS                                                                  254404
                  FID         NDIR        NDIR        CHEMI       CHEMI            254404
                  UHC          CO         CO2          NO          NOX             254404
RANGE              1           1           2            2           2              254404
INSTR GAS TEMP   153.         55.         55.         62.         62.              254404
RAW VALUE MV       8.2       550.4       578.3       392.2       448.3             254404
GAS CONCEN PPM(C)    3.7        52.9     27002.7        42.9        49.0           254404
GAS CONCEN PCT   0.0004      0.0053      2.7003      0.0043      0.0049            254404
EMISSION INDEX     0.14         3.9      3148.          5.2         6.0            254404
FUEL-AIR RATIO   0.0132                                                            254404
                                                                                   254404
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ENGINE TEST DATA
DATE                                                                            253304
08/13/76                     DATA POINT                  TEST CELL              253304
INSTRUMENT OPERATOR          253304                      13                     253304
ERHARDT                                                  TEST OPERATOR          253304
ENGINE MANUFACTURER                                      TREMBLEY               253304
LYCOMING                     MODEL                       SERIAL NUMBER          253304
FUEL IDENT.                  ALF-502                     LF02                   253304
JET-A HC RATIO 0.161         FUEL FLOW PPH               MANIFOLD FUEL TEMP FAH 253304
BELLMOUTH AIR FLOW LB/SEC     749.                       229.6                  253304
128.0                        CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.           253304
PT3 PSIA                     18.6                        0.0112                 253304
 70.8                        TT3 DEG. RANKINE                                   253304
PT9 PSIA                      919.4                                             253304
15.367                       TT9 DEG RANKINE             EPR                    253304
NET THRUST LBS               1208.8                       4.85                  253304
1662.0                       N1 RPM                      N2 RPM                 253304
ACTUAL INLET PRESSURE PO PSIA 15582.                     3562.                  253304
14.605                                                                          253304
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                        253304
536.9                                                                           253304
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                             253304
122.8                                                                           253304
FILTER AREA .385 SI                                                             253304
CLEAN CK SMOKE NUMBER 0                                                         253304
SMOKE NUMBER      VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH            253304
       6.7              3.0          0.52      11.096            87.0           253304
       6.7              4.0          0.52      11.096            87.0           253304
      10.9              7.0          0.53      11.096            87.0           253304
      14.9             11.0          0.53      11.096            87.0           253304
GASEOUS EMISSIONS                                                               253304
                   FID         NDIR        NDIR       CHEMI       CHEMI         253304
                   UHC         CO          CO2        NO          NOX           253304
RANGE              1           2           2          2           2             253304
INSTR GAS TEMP     153.        54.         54.        62.         62.           253304
RAW VALUE MV        23.6       311.2       494.3      253.7       328.6         253304
GAS CONCEN PPM(C)   15.3       130.0       22583.7      27.8        36.0        253304
GAS CONCEN PCT     0.0015      0.0130      2.2584     0.0028      0.0036        253304
EMISSION INDEX      0.67       11.5        3134.        4.0         5.2         253304
FUEL-AIR RATIO     0.0111                                                       253304
                                                                                253304
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ENGINE TEST DATA
DATE                                                                       252204
08/13/76                         DATA POINT           TEST CELL            252204
INSTRUMENT OPERATOR              252204               13                   252204
ERHARDT                                               TEST OPERATOR        252204
ENGINE MANUFACTURER                                   TREMBLEY             252204
LYCOMING                         MODEL                SERIAL NUMBER        252204
FUEL IDENT.                      ALF-502              LF02                 252204
JET-A HC RATIO 0.161             FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH 252204
BELLMOUTH AIR FLOW LB/SEC         435.                199.0                252204
 79.8                            CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS. 252204
PT3 PSIA                         11.7                 0.0103               252204
 41.0                            TT3 DEG. RANKINE                          252204
PT9 PSIA                          767.8                                    252204
14.906                           TT9 DEG RANKINE      EPR                  252204
NET THRUST LBS                   1201.9                2.80                252204
 599.0                           N1 RPM               N2 RPM               252204
ACTUAL INLET PRESSURE PO PSIA    12574.               2234.                252204
14.625                                                                     252204
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                   252204
535.7                                                                      252204
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                        252204
126.5                                                                      252204
FILTER AREA .385 SI                                                        252204
CLEAN CK SMOKE NUMBER 0                                                    252204
SMOKE NUMBER         VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH    252204
         0.0                3.0         0.50     11.001             86.0   252204
         2.3                4.0         0.52     11.050             86.0   252204
         2.3                7.0         0.50     11.050             86.0   252204
         4.5               11.0         0.52     11.050             85.0   252204
GASEOUS EMISSIONS                                                          252204
                     FID        NDIR       NDIR        CHEMI      CHEMI    252204
                     UHC        CO         CO2         NO         NOX      252204
RANGE                1          2          2           1          1        252204
INSTR GAS TEMP       153.       54.        54.         62.        62.      252204
RAW VALUE MV          92.3      710.5      473.8       517.0      841.3    252204
GAS CONCEN PPM(C)     67.1      350.7      21524.8        13.4       21.5  252204
GAS CONCEN PCT       0.0067     0.0351     2.1525      0.0013     0.0022   252204
EMISSION INDEX        3.06       32.1      3095.          2.0        3.2   252204
FUEL-AIR RATIO       0.0107                                                252204
                                                                           252204
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ENGINE TEST CATA                                                                      251114
CATE                          CATA PCINT              TEST CELL                       251114
C8/13/76                      251114                  13                              251114
INSTRUMENT CPERATCR                                   TEST OPERATOR                   251114
ERHARDT                                               TREMBLEY                        251114
ENGINE MANUFACTURER           MODEL                   SERIAL NUMBER                   251114
LYCCMING                      ALF-502                 LF02                            251114
FUEL IDENT.                   FUEL FLOW PPH           MANIFOLC FUEL TEMP FAH          251114
JET-A HC RATIO 0.161           358.                   182.2                           251114
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLCW LB/SEC     FUEL-AIR RATIO MEAS.            251114
 67.2                          9.7                    0.0103                          251114
PT3 PSIA                      TT3 DEG. RANKINE                                        251114
 33.8                          720.4                                                  251114
PT9 PSIA                      TT9 DEG RANKINE         EPR                             251114
14.825                        1204.4                   2.31                           251114
NET THRLST LBS                N1 RPM                  N2 RPM                          251114
 396.0                        11168.                  1847.                           251114
ACTUAL INLET PRESSURE PO PSIA                                                         251114
14.628                                                                                251114
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                              251114
536.3                                                                                 251114
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                   251114
123.9                                                                                 251114
FILTER AREA .385 SI                                                                   251114
CLEAN CK SMCKE NUMBER 0                                                               251114
SMOKE NUMBER        VCL.-LITERS      FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH              251114
        0.0                 3.0           0.52     11.050              87.0           251114
        C.0                 4.0           0.52     11.050              87.0           251114
        0.0                 7.C           0.52     11.C99              87.0           251114
        C.0                11.0           0.52     11.050              87.0           251114
GASEOUS EMISSICNS                                                                     251114
                    FID         NDIR        NDIR        CHEMI       CHEMI             251114
                    UHC          CO          CO2         NO          NOX              251114
RANGE               2           2           2           1           1                 251114
INSTR GAS TEMP      154.        53.         53.         62.         62.               251114
RAW VALLE MV         15.0       873.5       468.2       4C8.0       729.5             251114
GAS CCNCEN PPM(C)    11C.3       441.8       21237.C       1C.7        18.7           251114
GAS CCNCEN PCT      C.0110      0.C442      2.1237      C.CC11      0.C019            251114
EMISSION INDEX       5.06        4C.7       3075.         1.6         2.8             251114
FUEL-AIR RATIO      C.C1C6                                                            251114
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ENGINE TEST CATA              CATA PCINT           TEST CELL                 261105
DATE                          2611C5               13                        261105
C8/13/76                                           TEST OPERATOR             261105
INSTRUMENT CFERATOR                                TREMBLEY                  261105
ERHARDT                       MODEL                SERIAL NUMBER             261105
ENGINE MANUFACTURER           ALF-502              LF02                      261105
LYCCMING                      FUEL FLCW PPH        MANIFCLD FUEL TEMP FAH    261105
FUEL IDENT.                    359.                159.6                     261105
JET-A HC RATIO C.161          CORE AIRFLCW LB/SEC  FUEL-AIR RATIO MEAS.      261105
BELLMOUTH AIR FLCW LB/SEC      9.8                 C.0102                    261105
 67.1                         TT3 DEG. RANKINE                               261105
FT3 PSIA                       717.3                                         261105
 33.8                         TT5 DEG RANKINE      EPR                       261105
FT9 PSIA                      1197.3                2.31                     261105
14.820                        N1 RPM               N2 RPM                    261105
NET THRUST LBS                11148.               1856.                     261105
 395.0                                                                       261105
ACTUAL INLET PRESSURE PC PSIA                                                261105
14.625                                                                       261105
ACTUAL INLET TEMPERATURE TC DEG. RANKINE                                     261105
534.1                                                                        261105
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                          261105
118.0                                                                        261105
FILTER AREA .385 SI                                                          261105
CLEAN CK SMCKE NUMBER 0                                                      261105
SMOKE NUMBER      VCL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH        261105
        0.0               3.0         0.52     11.048           84.0         261105
        2.3               4.C         C.52     11.048           84.0         261105
        2.3               7.0         0.50     11.048           84.0         261105
        4.5              11.0         0.50     11.048           84.0         261105
GASEOUS EMISSICNS                                                            261105
                   FID        NDIR       NDIR       CHEMI      CHEMI         261105
                   UHC         CO         CO2         NO        NOX          261105
                    2          2          2           1          1           261105
RANGE              153.       53.        53.         62.        62.          261105
INSTR GAS TEMP      17.1      896.5      465.0      408.3      720.7         261105
RAW VALUE MV       125.5       455.4      21032.6      10.8       18.7       261105
GAS CCNCEN PPM(C)  C.0126     0.0455     2.1033     0.0011     0.0019        261105
GAS CCNCEN PCT      5.81       42.3      3070.         1.6        2.9        261105
EMISSION INDEX     C.0105                                                    261105
FUEL-AIR RATIO                                                               261105
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ENGINE TEST DATA                                                                     266705
DATE                          DATA POINT              TEST CELL                      266705
08/13/76                      266705                  13                             266705
INSTRUMENT OPERATOR                                   TEST OPERATOR                  266705
ERHARDT                                               TREMBLEY                       266705
ENGINE MANUFACTURER           MODEL                   SERIAL NUMBER                  266705
LYCOMING                      ALF-502                 LF02                           266705
FUEL IDENT.                   FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH         266705
JET-A HC RATIO 0.0            2544.                   237.0                          266705
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC     FUEL-AIR RATIO MEAS.           266705
232.1                         33.9                    0.0209                         266705
PT3 PSIA                      TT3 DEG. RANKINE                                       266705
154.4                        1161.6                                                  266705
PT9 PSIA                      TT9 DEG RANKINE         EPR                            266705
18.265                        1614.5                  10.63                          266705
NET THRUST LBS                N1 RPM                  N2 RPM                         266705
5985.0                        19490.                  6259.                          266705
ACTUAL INLET PRESSURE PO PSIA                                                        266705
14.560                                                                               266705
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                             266705
532.5                                                                                266705
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                  266705
119.0                                                                                266705
FILTER AREA .385 SI                                                                  266705
CLEAN CK SMOKE NUMBER 0                                                              266705
SMOKE NUMBER        VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH             266705
       20.6                 3.0          0.53      11.148           84.0             266705
       20.6                 4.0          0.52      11.148           84.0             266705
       30.8                 7.0          0.52      11.197           83.0             266705
       35.4                11.0          0.52      11.197           84.0             266705
GASEOUS EMISSIONS                                                                    266705
                   FID         NDIR         NDIR         CHEMI        CHEMI          266705
                   UHC          CO           CO2          NO           NOX           266705
RANGE               1           1            2            3            3             266705
INSTR GAS TEMP     153.        53.          53.          62.          62.            266705
RAW VALUE MV         4.7       120.4        891.2        388.2        418.7          266705
GAS CONCEN PPM(C)     1.5         8.7      45169.1        100.7        108.6         266705
GAS CONCEN PCT     0.0002      0.0009       4.5169       0.0101       0.0109         266705
EMISSION INDEX     0.03          0.4        3154.           7.4          7.9         266705
FUEL-AIR RATIO     0.0222                                                            266705
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ENGINE TEST CATA
DATE
C8/13/76                       CATA POINT          TEST CELL                     268605
INSTRUMENT CFERATCR            266605              13                            268605
ERHARDT                                            TEST OPERATOR                 268605
ENGINE MANUFACTURER                                TREMBLEY                      268605
LYCCMING                       MCDEL               SERIAL NUMBER                 268605
FUEL ICENT.                    ALF-502             LF02                          268605
JET-A HC RATIO 0.161           FUEL FLCW PPH       MANIFOLC FUEL TEMP FAH        268605
BELLMCUTH AIR FLCW LB/SEC      2263.               243.5                         268605
222.2                          CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.          268605
PT3 PSIA                       31.9                0.0197                        268605
143.7                          TT3 DEG. RANKINE                                  268605
PT9 PSIA                      1134.5                                             268605
17.722                         TT9 DEG RANKINE     EPR                           268605
NET THRLST LBS                 1559.9               9.89                         268605
5402.0                         N1 RPM              N2 RPM                        268605
ACTUAL INLET PRESSURE PC PSIA  19160.              6020.                         268605
14.556                                                                           268605
ACTUAL INLET TEMPERATURE TC DEG. RANKINE                                         268605
532.7                                                                            268605
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                              268605
121.1                                                                            268605
FILTER AREA .385 SI                                                              268605
CLEAN CK SMCKE NUMBER 0                                                          268605
SMOKE NUMBER          VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH        268605
          18.7                3.0         0.52    11.149              85.0       268605
          22.4                4.0         0.52    11.149              85.0       268605
          30.8                7.0         0.53    11.149              85.0       268605
          38.3               11.0         0.53    11.198              85.0       268605
GASEOLS EMISSICNS                                                                268605
                      FID         NDIR        NDIR        CHEMI      CHEMI       268605
RANGE                 UHC         CC          CC2         NO         NOX         268605
INSTR GAS TEMP        1           1           2           2          2           268605
RAW VALLE MV          153.        53.         53.         62.        62.         268605
GAS CCNCEN PPM(C)       4.0         97.2      845.9       808.0      876.4       268605
GAS CCNCEN PCT          1.0          6.7     42234.C        88.9        96.4     268605
EMISSICN INCEX        C.0001      C.CCC7      4.2234      0.CC89     0.C096      268605
FUEL-AIR RATIC        0.02        C.3         3154.        6.9        7.5        268605
                      C.02C8                                                     268605
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ENGINE TEST CATA                  CATA PCINT             TEST CELL                 267505
CATE                              267505                 13                        267505
C8/13/76                                                 TEST OPERATOR             267505
INSTRUMENT CPERATOR                                      TREMBLEY                  267505
ERHARDT                           MODEL                  SERIAL NUMBER             267505
ENGINE MANUFACTURER               ALF-502                LF02                      267505
LYCCMING                          FUEL FLCW PPH          MANIFCLD FUEL TEMP FAH    267505
FUEL IDENT.                       1259.                  244.2                     267505
JET-A HC RATIO C.161              CORE AIRFLCW LB/SEC    FUEL-AIR RATIO MEAS.      267505
BELLMCLTH AIR FLCW LB/SEC         24.7                   0.0142                    267505
171.4                             TT3 CEG. RANKINE                                 267505
PT3 PSIA                         1014.5                                            267505
100.6                             TT9 DEG RANKINE        EPR                       267505
PT9 PSIA                          1302.6                  6.90                     267505
16.073                            N1 RPM                 N2 RPM                    267505
NET THRLST LBS                    17336.                 4727.                     267505
3087.0                                                                             267505
ACTUAL INLET PRESSLRE PO PSIA                                                      267505
14.59C                                                                             267505
ACTUAL INLET TEMPERATURE TO DEG. FANKINE                                           267505
532.8                                                                              267505
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                267505
120.0                                                                              267505
FILTER AREA .385 SI                                                                267505
CLEAN CK SMCKE NUMBER C                                                            267505
SMOKE NUMBER          VOL.-LITERS     FLCW-CFM PRESS.-PSIA   TEMP. DEG.FAH         267505
        10.9                  3.0         0.52     11.149             85.0         267505
        14.9                  4.0         C.53     11.198             85.0         267505
        22.4                  7.0         C.53     11.198             85.0         267505
        27.6                 11.0         0.53     11.198             85.0         267505
GASEOUS EMISSICNS                                                                  267505
                     FID        NDIR       NCIR       CHEMI      CHEMI             267505
                     UHC        CC         CO2        NO         NOX               267505
RANGE                 1          1          2          2          2                267505
INSTR GAS TEMP       154.       53.        53.        62.        62.               267505
RAW VALLE MV           4.6      379.9      623.7      442.9      491.9             267505
GAS CCNCEN PPM(C)        1.5        34.5    29392.4       48.8       54.1          267505
GAS CCNCEN PCT       C.CCC2     0.0034     2.9392     0.CC49     0.0054            267505
EMISSION INDEX         0.05        2.4     3151.         5.5        6.1            267505
FUEL-AIR RATIO       C.0144                                                        267505
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ENGINE TEST DATA                                                                            264405
DATE                                                                                        264405
08/13/76                     DATA POINT              TEST CELL                              264405
INSTRUMENT OPERATOR          264405                  13                                     264405
ERHARDT                                              TEST OPERATOR                          264405
ENGINE MANUFACTURER          MODEL                   TREMBLEY                               264405
LYCOMING                     ALF-502                 SERIAL NUMBER                          264405
FUEL IDENT.                                          LF02                                   264405
JET-A HC RATIO 0.161         FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH                 264405
BELLMOUTH AIR FLOW LB/SEC    1095.                   233.8                                  264405
106.4                        CORE AIRFLOW LB/SEC     FUEL-AIR RATIO MEAS.                   264405
PT3 PSIA                     23.2                    0.0131                                 264405
 92.2                        TT3 DEG. RANKINE                                               264405
PT9 PSIA                       988.7                                                        264405
15.866                       TT9 DEG RANKINE         EPR                                    264405
NET THRUST LBS               1302.6                   6.32                                  264405
2651.0                       N1 RPM                  N2 RPM                                 264405
ACTUAL INLET PRESSURE PO PSIA 16906.                 4419.                                  264405
14.586                                                                                      264405
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                                    264405
532.5                                                                                       264405
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                         264405
123.0                                                                                       264405
FILTER AREA .385 SI                                                                         264405
CLEAN CK SMOKE NUMBER 0                                                                     264405
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM  PRESS.-PSIA   TEMP. DEG.FAH                    264405
      8.8                  3.0         0.52       11.198            84.0                    264405
     12.9                  4.0         0.53       11.149            84.0                    264405
     18.7                  7.0         0.53       11.149            84.0                    264405
     24.1                 11.0         0.53       11.149            84.0                    264405
GASEOUS EMISSIONS                                                                           264405
                   FID         NDIR         NDIR        CHEMI       CHEMI                   264405
                   UHC          CO          CO2          NO          NOX                    264405
RANGE               1           1            2            2           2                     264405
INSTR GAS TEMP     153.        56.          56.          62.         62.                    264405
RAW VALUE MV          5.9      547.5        582.5        389.6       446.3                  264405
GAS CONCEN PPM(C)       2.8       52.3      27212.9         42.6        48.7                264405
GAS CONCEN PCT     0.0003      0.0052       2.7213       0.0043      0.0049                 264405
EMISSION INDEX       0.10         3.9       3148.           5.2         5.9                 264405
FUEL-AIR RATIO     0.0133                                                                   264405
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ENGINF TEST CATA                                                                   263305
DATE                       CATA PCINT          TEST CELL                           263305
C8/13/76                   2633C5              13                                  263305
INSTRUMENT OPERATCR                            TEST OPERATOR                       263305
ERHARDT                                        TREMBLEY                            263305
ENGINE MANUFACTURER        MODEL               SERIAL NUMBER                       263305
LYCCMING                   ALF-502             LF02                                263305
FUEL IDENT.                FUEL FLCW PPH       MANIFOLC FUEL TEMP FAH              263305
JET-A HC RATIO 0.161        765.               221.6                               263305
BELLMCUTH AIR FLOW LB/SEC  CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.                263305
130.9                      18.9                0.0112                              263305
PT3 PSIA                   TT3 DEG. RANKINE                                        263305
 72.3                       917.1                                                  263305
PT9 PSIA                   TT9 DEG RANKINE     EPR                                 263305
15.4C8                     12C5.0               4.95                               263305
NET THRLST LBS             N1 RPM              N2 RPM                              263305
1722.0                     15652.              3617.                               263305
ACTUAL INLET PRESSURE FO PSIA                                                      263305
14.607                                                                             263305
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                           263305
533.0                                                                              263305
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                263305
121.9                                                                              263305
FILTER AREA .385 SI                                                                263305
CLEAN CK SMCKE NUMBER 0                                                            263305
SMOKE NUMBER         VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH           263305
         6.7                 3.0         0.52     11.100              84.0         263305
         6.7                 4.0         0.52     11.100              84.0         263305
         8.8                 7.0         0.52     11.100              84.0         263305
        14.9                11.0         0.53     11.149              84.0         263305
GASEOLS EMISSIONS                                                                  263305
                     FID         NDIR       NDIR       CHEMI      CHEMI            263305
                     UHC          CC         CO2        NO         NOX             263305
RANGE                 1           2          2          2          2               263305
INSTR GAS TEMP       153.        56.        56.        62.        62.              263305
RAW VALUE MV          20.4       305.7      496.0      255.0      329.9            263305
GAS CCNCEN PPM(C)     13.7        127.0      22660.8       27.9       36.0         263305
GAS CCNCEN PCT       0.0014      0.C127     2.2661     0.0028     0.C036           263305
EMISSION INCEX        0.60        11.2      3135.         4.0        5.2           263305
FUEL-AIR RATIO       C.C111                                                        263305
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ENGINE TEST DATA                                                                  262205
DATE                         DATA POINT              TEST CELL                    262205
08/13/76                     262205                  13                           262205
INSTRUMENT OPERATOR                                  TEST OPERATOR                262205
ERHARDT                                              TREMBLEY                     262205
ENGINE MANUFACTURER          MODEL                   SERIAL NUMBER                262205
LYCOMING                     ALF-502                 LF02                         262205
FUEL IDENT.                  FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH       262205
JET-A HC RATIO 0.161          436.                   187.6                        262205
BELLMOUTH AIR FLOW LB/SEC    CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.             262205
 81.0                        11.8                    0.0103                       262205
FT3 PSIA                     TT3 DEG. RANKINE                                     262205
 40.9                         762.5                                               262205
FT9 PSIA                     TT9 DEG RANKINE         EPR                          262205
14.906                       1194.8                   2.79                        262205
NET THRUST LBS               N1 RPM                  N2 RPM                       262205
 599.0                       12530.                  2216.                        262205
ACTUAL INLET PRESSURE PO PSIA                                                     262205
14.626                                                                            262205
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                          262205
533.3                                                                             262205
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                               262205
121.8                                                                             262205
FILTER AREA .385 SI                                                               262205
CLEAN CK SMOKE NUMBER 0                                                           262205
SMOKE NUMBER        VOL.-LITERS   FLOW-CFM PRESS.-PSIA   TEMP. DEG.FAH            262205
        0.0                 3.0       0.52      11.050             83.0           262205
        0.0                 4.0       0.52      11.100             83.0           262205
        2.3                 7.0       0.50      11.050             83.0           262205
        6.7                11.0       0.52      11.050             83.0           262205
GASEOUS EMISSIONS                                                                 262205
                    FID        NDIR       NDIR        CHEMI       CHEMI           262205
                    UHC         CO         CO2         NO          NOX            262205
RANGE                1          2          2           1           1              262205
INSTR GAS TEMP      153.       56.        56.         62.         62.             262205
RAW VALUE MV        109.3      750.5      469.9       492.9       827.3           262205
GAS CONCEN PPM(C)    80.7      371.5     21314.5        12.9        21.4          262205
GAS CONCEN PCT      0.0081     0.0371     2.1314      0.0013      0.0021          262205
EMISSION INDEX       3.71       34.3      3089.          2.0         3.2          262205
FUEL-AIR RATIO      0.0106                                                        262205
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ENGINE TEST CATA                                                                    261115
DATE                         CATA PCINT            TEST CELL                        261115
C8/13/76                     261115                13                               261115
INSTRUMENT CPERATOR                                TEST OPERATOR                    261115
ERHARCT                                            TREMBLEY                         261115
ENGINE MANUFACTURER          MCDEL                 SERIAL NUMBER                    261115
LYCCMING                     ALF-502               LF02                             261115
FUEL IDENT.                  FUEL FLCW PPH         MANIFOLC FUEL TEMP FAH           261115
JET-A HC RATIO C.161          356.                 173.9                            261115
BELLMCUTH AIR FLCW LB/SEC    CORE AIRFLCW LB/SEC FUEL-AIR RATIO MEAS.               261115
 66.4                        9.6                   0.0103                           261115
PT3 PSIA                     TT3 DEG. RANKINE                                       261115
 33.8                         715.8                                                 261115
PT9 PSIA                     TT9 DEG RANKINE       EPR                              261115
14.828                       1199.4                 2.31                            261115
NET THRLST LBS               N1 RPM                N2 RPM                           261115
 397.0                       11122.                1836.                            261115
ACTUAL INLET PRESSLRE PC PSIA                                                       261115
14.633                                                                              261115
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                            261115
533.3                                                                               261115
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                 261115
121.3                                                                               261115
FILTER AREA .385 SI                                                                 261115
CLEAN CK SMCKE NUMBER 0                                                             261115
SMOKE NUMBER         VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH            261115
         2.3                3.0          0.50      11.049            83.0           261115
         2.3                4.0          0.52      11.049            83.0           261115
         2.3                7.0          0.52      11.049            83.0           261115
         4.5               11.0          C.52      11.049            83.0           261115
GASEOLS EMISSICNS                                                                   261115
                     FID       NDIR      NDIR       CHEMI      CHEMI                261115
                     UHC        CC        CO2        NO         NOX                 261115
RANGE                 2         2          2         1          1                   261115
INSTR GAS TEMP       154.      56.        56.        62.        62.                 261115
RAW VALUE MV          16.7     897.8      464.1      399.8      721.6               261115
GAS CCNCEN PPM(C)     123.8     454.3      21017.4     10.5       18.7              261115
GAS CCNCEN PCT       C.0124    0.C454     2.1017     0.0011     0.C019              261115
EMISSICN INDEX        5.73      42.2      3070.        1.6        2.9               261115
FUEL-AIR RATIO       C.0105                                                         261115
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ENGINE TEST CATA                                                                       271106
DATE                          CATA PCINT          TEST CELL                            271106
C8/14/76                      2711C6              13                                   271106
INSTRUMENT OPERATOR                               TEST OPERATOR                        271106
ERHARDT                                           TREMBLEY                             271106
ENGINE MANUFACTURER           MODEL               SEPIAL NUMBER                        271106
LYCCMING                      ALF-502             LFC2                                 271106
FUEL IDENT.                   FUEL FLCW PPH       MANIFOLC FUEL TEMP FAH               271106
JET-A HC RATIO C.161           377.               168.4                                271106
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLCW LB/SEC FUEL-AIR RATIO MEAS.                 271106
 66.4                          9.2                0.0114                               271106
PT3 PSIA                      TT3 DEG. RANKINE                                         271106
 33.2                          716.0                                                   271106
PT9 PSIA                      TT9 DEG RANKINE      EPR                                 271106
14.866                        1264.0                2.27                               271106
NET THRUST LBS                N1 RFM              N2 RPM                               271106
 399.0                        10934.              1868.                                271106
ACTUAL INLET PRESSURE PO PSIA                                                          271106
14.684                                                                                 271106
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                               271106
538.2                                                                                  271106
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                    271106
113.5                                                                                  271106
FILTER AREA .385 SI                                                                    271106
CLEAN CK SMCKE NUMBER 0                                                                2711C6
SMCKE NUMBER         VCL.-LITERS      FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH              271106
         0.C                 3.0          0.52     11.090             84.0             271106
         0.0                 4.C          C.52     11.139             84.0             271106
         2.3                 7.0          0.53     11.139             84.0             271106
         2.3                11.0          C.52     11.139             84.0             271106
GASEOUS EMISSICNS                                                                      271106
                    FID         NDIR        NCIR        CHEMI       CHEMI              271106
                    UHC          CC          CO2         NO          NOX               271106
RANGE                1           2           2           1           1                 271106
INSTR GAS TEMP      153.        55.         55.         62.         62.                271106
RAW VALLE MV        137.8       889.1       515.0       450.1       814.8              271106
GAS CCNCEN PPM(C)    101.9       447.6       23312.C       11.7        20.9            271106
GAS CCNCEN PCT      C.0102      0.C448      2.3312      C.CC12      0.C021             271106
EMISSICN INDEX       4.27        37.7       3082.          1.6         2.9             2711C6
FUEL-AIR RATIO      C.0116                                                             271106
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ENGINE TEST DATA
DATE                                                              276706
08/14/76                  DATA POINT            TEST CELL         276706
INSTRUMENT OPERATOR       276706                13                276706
ERHARDT                                         TEST OPERATOR     276706
ENGINE MANUFACTURER                             TREMBLEY          276706
LYCOMING                  MODEL                 SERIAL NUMBER     276706
FUEL IDENT.               ALF-502               LF02              276706
JET-A HC RATIO 0.161      FUEL FLOW PPH         MANIFOLD FUEL TEMP FAH  276706
BELLMOUTH AIR FLOW LB/SEC 2485.                 240.6             276706
227.9                     CORE AIRFLOW LB/SEC   FUEL-AIR RATIO MEAS.  276706
PT3 PSIA                  33.0                  0.0209            276706
150.7                     TT3 DEG. RANKINE                        276706
PT9 PSIA                 1159.1                                   276706
18.103                    TT9 DEG RANKINE       EPR               276706
NET THRUST LBS            1616.7                10.34             276706
5828.0                    N1 RPM                N2 RPM            276706
ACTUAL INLET PRESSURE PC PSIA  19384.           6223.             276706
14.587                                                            276706
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                          276706
535.8                                                             276706
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                               276706
111.9                                                             276706
FILTER AREA .385 SI                                               276706
CLEAN CK SMOKE NUMBER 0                                           276706
SMOKE NUMBER      VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH  276706
       14.9              3.0         0.53     11.237          85.0    276706
       22.4              4.0         0.53     11.237          85.0    276706
       27.6              7.0         0.54     11.237          85.0    276706
       36.9             11.0         0.53     11.237          85.0    276706
GASEOUS EMISSIONS                                                 276706
                  FID       NDIR      NDIR       CHEMI     CHEMI  276706
                  UHC       CO        CO2        NO        NOX    276706
RANGE             1         1         2          3         3      276706
INSTR GAS TEMP    153.      54.       54.        62.       62.    276706
RAW VALUE MV        8.2     120.2     899.8      397.1     421.7  276706
GAS CONCEN PPM(C)   4.2       8.8     45127.8      102.6     109.0  276706
GAS CONCEN PCT    0.0004    0.0009    4.5128     0.0103    0.0109  276706
EMISSION INDEX    0.09        0.4     3154.        7.5       8.0  276706
FUEL-AIR RATIO    0.0222                                          276706
                                                                  276706
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ENGINE TEST DATA
DATE                    DATA POINT         TEST CELL                         278606
08/14/76                278606             13                                278606
INSTRUMENT OPERATOR                        TEST OPERATOR                     278606
ERHARDT                                    TREMBLEY                          278606
ENGINE MANUFACTURER     MODEL              SERIAL NUMBER                     278606
LYCOMING                ALF-502            LF02                              278606
FUEL IDENT.             FUEL FLOW PPH      MANIFOLD FUEL TEMP FAH            278606
JET-A HC RATIO 0.161    2198.              249.5                             278606
BELLMOUTH AIR FLOW LB/SEC CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.           278606
217.7                   31.2               0.0196                            278606
PT3 PSIA                TT3 DEG. RANKINE                                     278606
140.3                  1134.1                                                278606
PT9 PSIA                TT9 DEG RANKINE    EPR                               278606
17.595                  1567.6              9.63                             278606
NET THRUST LBS          N1 RPM             N2 RPM                            278606
5250.0                  19052.             5962.                             278606
ACTUAL INLET PRESSURE PC PSIA                                                278606
14.598                                                                       278606
ACTUAL INLET TEMPERATURE TC DEG. RANKINE                                     278606
537.0                                                                        278606
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                          278606
109.9                                                                        278606
FILTER AREA .385 SI                                                          278606
CLEAN CK SMOKE NUMBER 0                                                      278606
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH       278606
        16.8                3.0         0.53      11.237            85.0     278606
        20.6                4.0         0.53      11.188            85.0     278606
        30.8                7.0         0.55      11.188            85.0     278606
        35.4               11.0         0.53      11.237            85.0     278606
GASEOUS EMISSIONS                                                            278606
                   FID        NDIR       NDIR       CHEMI       CHEMI        278606
                   UHC        CO         CO2        NO          NOX          278606
RANGE              1          1          2          2           2            278606
INSTR GAS TEMP     153.       53.        53.        62.         62.          278606
RAW VALUE MV         7.2      96.2       850.5      827.9       900.2        278606
GAS CONCEN PPM(C)    3.4        6.7      41966.1      90.8        98.7       278606
GAS CONCEN PCT     0.0003     0.0007     4.1966     0.0091      0.0099       278606
EMISSION INDEX       0.08       0.3      3154.        7.1         7.8        278606
FUEL-AIR RATIO     0.0206                                                    278606
                                                                             278606
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ENGINE TEST DATA
DATE                         DATA POINT          TEST CELL                  277506
08/14/76                     277506              13                         277506
INSTRUMENT OPERATOR                                                         277506
ERHARDT                                          TEST OPERATOR              277506
ENGINE MANUFACTURER                              TREMBLEY                   277506
LYCOMING                     MODEL               SERIAL NUMBER              277506
FUEL IDENT.                  ALF-502             LF02                       277506
JET-A HC RATIO 0.161         FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH     277506
BELLMOUTH AIR FLOW LB/SEC    1208.               249.4                      277506
165.2                        CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.       277506
PT3 PSIA                     24.0                0.0140                     277506
 97.0                        TT3 DEG. RANKINE                               277506
PT9 PSIA                    1010.8                                          277506
16.024                       TT9 DEG RANKINE     EPR                        277506
NET THRUST LBS               1358.6               6.64                      277506
2930.0                       N1 RPM              N2 RPM                     277506
                             17176.              4649.                      277506
ACTUAL INLET PRESSURE PO PSIA                                               277506
14.631                                                                      277506
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                    277506
537.2                                                                       277506
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         277506
108.1                                                                       277506
FILTER AREA .385 SI                                                         277506
CLEAN CK SMOKE NUMBER 0                                                     277506
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH     277506
        8.8                3.0        0.52      11.087             85.0     277506
       10.9                4.0        0.52      11.087             85.0     277506
       20.6                7.0        0.50      11.087             85.0     277506
       27.6               11.0        0.50      11.087             85.0     277506
GASEOUS EMISSIONS                                                           277506
                   FID        NDIR       NDIR        CHEMI      CHEMI       277506
                   UHC         CO         CO2         NO         NOX        277506
RANGE               1          1          2           2          2          277506
INSTR GAS TEMP     154.       53.        53.         62.        62.         277506
RAW VALUE MV         8.3     372.8      627.2       461.8      511.9        277506
GAS CONCEN PPM(C)     4.2       33.9     29212.7       50.5       56.0      277506
GAS CONCEN PCT     0.0004     0.0034     2.9213      0.0051     0.0056      277506
EMISSION INDEX     0.14        2.3      3151.          5.7        6.3       277506
FUEL-AIR RATIO     0.0143                                                   277506
                                                                            277506
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ENGINE TEST DATA                                                                          274406
DATE                         DATA POINT              TEST CELL                            274406
08/14/76                     274406                  13                                   274406
INSTRUMENT OPERATOR                                  TEST OPERATOR                        274406
ERHARDT                                              TREMBLEY                             274406
ENGINE MANUFACTURER          MODEL                   SERIAL NUMBER                        274406
LYCOMING                     ALF-502                 LF02                                 274406
FUEL IDENT.                  FUEL FLOW PPH           MANIFOLD FUEL TEMP FAH               274406
JET-A HC RATIO 0.161         1038.                   236.7                                274406
BELLMOUTH AIR FLOW LB/SEC    CORE AIRFLOW LB/SEC     FUEL-AIR RATIO MEAS.                 274406
153.4                        22.0                    0.0131                               274406
PT3 PSIA                     TT3 DEG. RANKINE                                             274406
 87.3                         980.8                                                       274406
PT9 PSIA                     TT9 DEG RANKINE         EPR                                  274406
15.774                       1311.9                   5.96                                274406
NET THRUST LBS               N1 RPM                  N2 RPM                               274406
2436.0                       16682.                  4264.                                274406
ACTUAL INLET PRESSURE PO PSIA                                                             274406
14.639                                                                                    274406
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                                  274406
539.0                                                                                     274406
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                       274406
110.7                                                                                     274406
FILTER AREA .385 SI                                                                       274406
CLEAN CK SMOKE NUMBER 0                                                                   274406
SMOKE NUMBER          VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH                274406
         10.9                 3.0           0.52     11.087             86.0              274406
         12.9                 4.0           0.52     11.137             86.0              274406
         14.9                 7.0           0.52     11.137             86.0              274406
         24.1                11.0           0.52     11.137             86.0              274406
GASEOUS EMISSIONS                                                                         274406
                   FID        NDIR       NDIR        CHEMI       CHEMI                    274406
                   UHC        CO         CO2         NO          NOX                      274406
RANGE               1          1          2           2           2                       274406
INSTR GAS TEMP     153.       54.        54.         62.         62.                      274406
RAW VALUE MV         9.6      569.8      565.0       392.6       456.2                    274406
GAS CONCEN PPM(C)    3.3       55.0    27112.3        43.1        50.1                    274406
GAS CONCEN PCT     0.0003     0.0055     2.7112      0.0043      0.0050                   274406
EMISSION INDEX     0.12        4.1      3148.          5.2         6.1                    274406
FUEL-AIR RATIO     0.0133                                                                 274406
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ENGINE TEST DATA                                                            273306
DATE                        DATA POINT           TEST CELL                  273306
08/14/76                    273306               13                         273306
INSTRUMENT OPERATOR                              TEST OPERATOR              273306
ERHARDT                                          TREMBLEY                   273306
ENGINE MANUFACTURER         MODEL                SERIAL NUMBER              273306
LYCOMING                    ALF-502              LF02                       273306
FUEL IDENT.                 FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH     273306
JET-A HC RATIO 0.161         702.                225.8                      273306
BELLMOUTH AIR FLOW LB/SEC   CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.       273306
122.2                       17.6                 0.0111                     273306
PT3 PSIA                    TT3 DEG. RANKINE                                273306
 66.9                        903.3                                          273306
PT9 PSIA                    TT9 DEG RANKINE      EPR                        273306
15.330                      1215.4                4.57                      273306
NET THRUST LBS              N1 RPM               N2 RPM                     273306
1533.0                      15196.               3419.                      273306
ACTUAL INLET PRESSURE PO PSIA                                               273306
14.651                                                                      273306
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                    273306
538.0                                                                       273306
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                         273306
111.0                                                                       273306
FILTER AREA .385 SI                                                         273306
CLEAN CK SMOKE NUMBER 0                                                     273306
SMOKE NUMBER       VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH      273306
        4.5                3.0         0.52      11.086             85.0    273306
        4.5                4.0         0.53      11.135             85.0    273306
       10.9                7.0         0.52      11.135             85.0    273306
       12.9               11.0         0.52      11.135             85.0    273306
GASEOUS EMISSIONS                                                           273306
                  FID        NDIR        NDIR        CHEMI       CHEMI      273306
                  UHC         CO         CO2          NO          NOX       273306
RANGE             1           2          2           2           2          273306
INSTR GAS TEMP    154.        54.        54.         62.         62.        273306
RAW VALUE MV       25.3       342.3      499.2       245.4       327.0      273306
GAS CONCEN PPM(C)   15.4       143.2      22627.4       27.0        35.9    273306
GAS CONCEN PCT    0.0015      0.0143     2.2627      0.0027      0.0036     273306
EMISSION INDEX     0.68       12.6       3133.          3.9         5.2     273306
FUEL-AIR RATIO    0.0111
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ENGINE TEST CATA                                                                        272206
CATE                        CATA PCINT           TEST CELL                              272206
C8/14/76                    272206               13                                     272206
INSTRUMENT CPERATOR                              TEST CPERATOR                          272206
ERHARDT                                          TREMBLEY                               272206
ENGINE MANUFACTURER         MODEL                SERIAL NUMBER                          272206
LYCCMING                    ALF-502              LF02                                   272206
FUEL IDENT.                 FUEL FLCW PPH        MANIFCLC FUEL TEMP FAH                 272206
JET-A HC RATIO C.161         452.                193.2                                  272206
BELLMCUTH AIR FLCW LB/SEC   CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.                   272206
 78.4                       11.4                 0.0111                                 272206
FT3 PSIA                    TT3 DEG. RANKINE                                            272206
 39.9                        764.7                                                      272206
PT9 PSIA                    TT9 DEG RANKINE      EPR                                    272206
14.934                      1253.0                2.72                                  272206
NET THRLST LBS              N1 FFM               N2 RPM                                 272206
 595.0                      12336.               2211.                                  272206
ACTUAL INLET PRESSURE PO PSIA                                                           272206
14.664                                                                                  272206
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                                272206
540.4                                                                                   272206
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                     272206
110.9                                                                                   272206
FILTER AREA .385 SI                                                                     272206
CLEAN CK SMCKE NUMBER 0                                                                 272206
SMOKE NUMBER       VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH                  272206
        0.0                3.0         0.52      11.C85              85.0               272206
        0.C                4.C         0.50      11.C85              85.0               272206
        2.3                7.C         0.52      11.C85              85.0               272206
        4.5               11.0         0.52      11.135              85.0               272206
GASEOUS EMISSIONS                                                                       272206
                   FID         NDIR       NDIR        CHEMI       CHEMI                 272206
                   UHC         CC         CO2         NO          NOX                   272206
RANGE               1          2          2           1           1                     272206
INSTR GAS TEMP     154.        53.        53.         62.         62.                   272206
RAW VALLE MV        86.3       725.4      509.7       547.6       912.4                 272206
GAS CCNCEN PPM(C)    62.2       356.8      23166.6        14.3        23.5              272206
GAS CCNCEN PCT     C.C062      C.C357     2.3167      C.C014      0.C024                272206
EMISSION INDEX      2.64       30.4       3099.          2.0         3.3                272206
FUEL-AIR RATIO     C.0115                                                               272206
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ENGINE TEST CATA                                                                        271116
CATE                          DATA PCINT              TEST CELL                         271116
C8/14/76                      271116                  13                                271116
INSTRUMENT CPERATOR                                   TEST CPERATOR                     271116
ERHARDT                                               TREMBLEY                          271116
ENGINE MANUFACTURER           MCDEL                   SERIAL NUMBER                     271116
LYCOMING                      ALF-502                 LF02                              271116
FUEL IDENT.                   FUEL FLCW PPH           MANIFCLD FUEL TEMP FAH            271116
JET-A HC RATIO C.161           379.                   177.7                             271116
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLOW LB/SEC     FUEL-AIR RATIO MEAS.              271116
 65.7                          9.3                    0.0114                            271116
PT3 PSIA                      TT3 CEG. RANKINE                                          271116
 33.0                          716.4                                                    271116
PT9 PSIA                      TT9 DEG RANKINE         EPR                               271116
14.853                        1273.3                   2.25                             271116
NET THRUST LBS                N1 RPM                  N2 RPM                            271116
 400.0                        1C886.                  1859.                             271116
ACTUAL INLET PRESSURE PC PSIA                                                           271116
14.670                                                                                  271116
ACTUAL INLET TEMPERATURE TC CEG. RANKINE                                                271116
539.7                                                                                   271116
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                                     271116
110.9                                                                                   271116
FILTER AREA .385 SI                                                                     271116
CLEAN CK SMCKE NUMBER 0                                                                 271116
SMCKE NUMBER        VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH                 271116
        0.0                 3.0         C.50     11.C84             86.0                271116
        C.C                 4.0         C.5C     11.C84             86.C                271116
        2.3                 7.0         0.52     11.C84             86.0                271116
        4.5                11.C         C.50     11.CE4             86.0                271116
GASEOUS EMISSICNS                                                                       271116
                    FID       NDIR      NCIR       CHEMI     CHEMI                      271116
                    UHC        CC        CO2        NO        NOX                       271116
RANGE                1         2         2          1         1                         271116
INSTR GAS TEMP      154.      53.       53.        62.       62.                        271116
RAW VALUE MV        141.C     502.7     514.4      439.8     812.9                      271116
GAS CCNCEN PPM(C)    104.2     456.1     23408.1      11.5      21.0                    271116
GAS CONCEN PCT      C.01C4    C.C456    2.3408     0.0012    0.0021                     271116
EMISSION INCEX       4.35      38.2     3081.         1.6       2.9                     271116
FUEL-AIR RATIO      C.C117                                                              271116
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ENGINE TEST CATA                                                                 281107
CATE                          CATA PCINT             TEST CELL                   281107
C8/16/76                      281107                 13                          281107
INSTRUMENT CPERATOR                                  TEST CPERATOR               281107
ERHARDT                                              TREMBLEY                    281107
ENGINE MANUFACTURER           MODEL                  SERIAL NUMBER               281107
LYCOMING                      ALF-502                LF02                        281107
FUEL IDENT.                   FUEL FLCW PPH          MANIFCLC FUEL TEMP FAH      281107
JET-A HC RATIO C.161           375.                  153.8                       281107
BELLMCUTH AIR FLCW LB/SEC     CORE AIRFLCW LB/SEC FUEL-AIR RATIO MEAS.           281107
 67.1                          9.5                   0.0110                      281107
PT3 PSIA                      TT3 DEG. RANKINE                                   281107
 33.4                          701.2                                             281107
PT9 PSIA                      TT9 CEG RANKINE        EPR                         281107
14.904                        1241.3                  2.27                       281107
NET THRUST LBS                N1 RPM                 N2 RPM                      281107
 415.C                        10818.                 1835.                       281107
ACTUAL INLET PRESSURE PO PSIA                                                    281107
14.713                                                                           281107
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                         281107
525.5                                                                            281107
SPECIFIC HUMIDITY GRAINS/LB CRY AIR                                              281107
 62.4                                                                            281107
FILTER AREA .385 SI                                                              281107
CLEAN CK SMCKE NUMBER 0                                                          281107
SMOKE NUMBER        VOL.-LITERS     FLCW-CFM PRESS.-PSIA  TEMP. DEG.FAH          281107
        0.0                 3.0          0.48      10.298            74.0        281107
        C.C                 4.0          0.48      10.298            74.0        281107
        2.3                 7.C          0.48      10.298            74.0        281107
        2.3                11.0          C.48      10.298            74.0        281107
GASECUS EMISSIONS                                                                281107
                    FID         NDIR        NDIR        CHEMI       CHEMI        281107
                    UHC          CC          CO2         NO          NOX         281107
RANGE                2           2           2           1           1           281107
INSTR GAS TEMP      153.        60.         6C.         61.         61.          281107
RAW VALUE MV         15.7       550.5       527.7       472.1       872.4        281107
GAS CCNCEN PPM(C)    120.3       486.3       22802.3       11.5        21.3      281107
GAS CCNCEN PCT      C.0120      0.C486      2.2802      0.C012      0.C021       281107
EMISSICN INDEX       5.14        41.7       3076.          1.6         3.0       281107
FUEL-AIR RATIC      C.0114                                                       281107
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ENGINE TEST DATA                                                                          286707
DATE                        DATA POINT                 TEST CELL                          286707
08/16/76                    286707                     13                                 286707
INSTRUMENT OPERATOR                                    TEST OPERATOR                      286707
ERHARDT                                                TREMBLEY                           286707
ENGINE MANUFACTURER         MODEL                      SERIAL NUMBER                      286707
LYCOMING                    ALF-502                    LF02                               286707
FUEL IDENT.                 FUEL FLOW PPH              MANIFOLD FUEL TEMP FAH             286707
JET-A HC RATIO 0.161        2582.                      232.3                              286707
BELLMOUTH AIR FLOW LB/SEC   CORE AIRFLOW LB/SEC        FUEL-AIR RATIO MEAS.               286707
236.6                       34.6                       0.0208                             286707
PT3 PSIA                    TT3 DEG. RANKINE                                              286707
157.6                      1149.8                                                         286707
PT9 PSIA                    TT9 DEG RANKINE            EPR                                286707
18.552                      1614.0                     10.79                              286707
NET THRUST LBS              N1 RPM                     N2 RPM                             286707
6245.0                      19378.                     6236.                              286707
ACTUAL INLET PRESSURE FC PSIA                                                             286707
14.627                                                                                    286707
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                                  286707
523.3                                                                                     286707
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                       286707
 62.1                                                                                     286707
FILTER AREA .385 SI                                                                       286707
CLEAN CK SMOKE NUMBER 0                                                                   286707
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH                   286707
         16.8                3.0          0.48    10.300              74.0                286707
         20.6                4.0          0.50    10.300              74.0                286707
         27.6                7.0          0.50    10.300              74.0                286707
         35.4               11.0          0.50    10.300              75.0                286707
GASEOUS EMISSIONS                                                                         286707
                    FID          NDIR         NDIR         CHEMI        CHEMI             286707
                    UHC          CO           CO2          NO           NOX               286707
RANGE               1            1            2            3            3                 286707
INSTR GAS TEMP      153.         54.          54.          60.          61.               286707
RAW VALUE MV          3.2        142.1        941.0        467.4        503.1             286707
GAS CONCEN PPM(C)       3.6         11.1      45154.3        115.2        124.1           286707
GAS CONCEN PCT      0.0004       0.0011       4.5154       0.0115       0.0124            286707
EMISSION INDEX       0.08          0.5        3156.          8.4          9.0             286707
FUEL-AIR RATIO      0.0222                                                                286707
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ENGINE TEST DATA                                                                       288607
DATE                        DATA POINT          TEST CELL                              288607
08/16/76                    288607              13                                     288607
INSTRUMENT OPERATOR                             TEST OPERATOR                          288607
ERHARDT                                         TREMBLEY                               288607
ENGINE MANUFACTURER         MODEL               SERIAL NUMBER                          288607
LYCOMING                    ALF-502             LF02                                   288607
FUEL IDENT.                 FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH                 288607
JET-A HC RATIO 0.161        2294.               237.6                                  288607
BELLMOUTH AIR FLOW LB/SEC   CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.                   288607
227.6                       32.6                0.0196                                 288607
PT3 PSIA                    TT3 DEG. RANKINE                                           288607
146.1                      1122.8                                                      288607
PT9 PSIA                    TT9 DEG RANKINE     EPR                                    288607
17.902                      1554.4               9.99                                  288607
NET THRUST LBS              N1 RPM              N2 RPM                                 288607
5632.0                      19038.              5982.                                  288607
ACTUAL INLET PRESSURE PO PSIA                                                          288607
14.649                                                                                 288607
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                               288607
523.3                                                                                  288607
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                    288607
 61.5                                                                                  288607
FILTER AREA .385 SI                                                                    288607
CLEAN CK SMOKE NUMBER 0                                                                288607
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH                288607
        14.9                3.0         0.48     10.300                74.0            288607
        22.4                4.0         0.48     10.300                74.0            288607
        27.6                7.0         0.48     10.300                74.0            288607
        35.4               11.0         0.48     10.300                74.0            288607
GASEOUS EMISSIONS                                                                      288607
                    FID        NDIR       NDIR       CHEMI      CHEMI                  288607
                    UHC        CO         CO2        NO         NOX                    288607
RANGE               1          1          2          3          3                      288607
INSTR GAS TEMP      153.       51.        51.        60.        60.                    288607
RAW VALUE MV          2.3      113.2      856.4      391.4      425.7                  288607
GAS CONCEN PPM(C)       2.9        8.6    42412.6        96.3      104.8               288607
GAS CONCEN PCT      0.0003     0.0009     4.2413     0.0096     0.0105                 288607
EMISSION INDEX       0.07        0.4      3157.         7.5        8.2                 288607
FUEL-AIR RATIO      0.0208                                                             288607
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ENGINE TEST DATA                                                          287507
DATE                          DATA POINT          TEST CELL               287507
08/16/76                      287507              13                      287507
INSTRUMENT OPERATOR                               TEST OPERATOR           287507
ERHARDT                                           TREMBLEY                287507
ENGINE MANUFACTURER           MODEL               SERIAL NUMBER           287507
LYCOMING                      ALF-502             LF02                    287507
FUEL IDENT.                   FUEL FLOW PPH       MANIFOLD FUEL TEMP FAH  287507
JET-A HC RATIO 0.161          1281.               233.4                   287507
BELLMOUTH AIR FLOW LB/SEC     CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.    287507
176.3                         25.3                0.0140                  287507
PT3 PSIA                      TT3 DEG. RANKINE                            287507
102.7                        1000.5                                       287507
PT9 PSIA                      TT9 DEG RANKINE     EPR                     287507
16.198                        1341.5               7.00                   287507
NET THRUST LBS                N1 RPM              N2 RPM                  287507
3227.0                        17178.              4752.                   287507
ACTUAL INLET PRESSURE PO PSIA                                             287507
14.677                                                                    287507
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                  287507
522.7                                                                     287507
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                       287507
 61.2                                                                     287507
FILTER AREA .385 SI                                                       287507
CLEAN CK SMOKE NUMBER 0                                                   287507
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH   287507
        12.9                3.0         0.50      10.299           74.0   287507
        14.9                4.0         0.50      10.299           74.0   287507
        22.4                7.0         0.50      10.299           74.0   287507
        29.2               11.0         0.50      10.299           74.0   287507
GASEOUS EMISSIONS                                                         287507
                    FID       NDIR      NDIR      CHEMI     CHEMI         287507
                    UHC        CO       CO2        NO        NOX          287507
RANGE                1         1         2         2         2            287507
INSTR GAS TEMP      153.      52.       52.       60.       60.           287507
RAW VALUE MV          2.3    364.3      659.9     534.0     596.6         287507
GAS CONCEN PPM(C)      2.4      31.9     29392.9      56.4      63.1      287507
GAS CONCEN PCT      0.0002   0.0032     2.9393    0.0056    0.0063        287507
EMISSION INDEX      0.08        2.2     3154.        6.3       7.1        287507
FUEL-AIR RATIO      0.0144                                                287507
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ENGINE TEST CATA
CATE                                                                          284407
C8/16/76                          DATA POINT            TEST CELL             284407
INSTRUMENT OPERATOR               2844C7                13                    284407
ERHARDT                                                 TEST OPERATOR         284407
ENGINE MANUFACTURER               MODEL                 TREMBLEY              284407
LYCOMING                          ALF-502               SERIAL NUMBER         284407
FUEL IDENT.                       FUEL FLOW PPH         LF02                  284407
JET-A HC RATIO C.161              1135.                 MANIFOLD FUEL TEMP FAH 284407
BELLMOUTH AIR FLOW LB/SEC                               227.0                 284407
164.8                             CORE AIRFLOW LB/SEC   FUEL-AIR RATIO MEAS.  284407
FT3 PSIA                          23.9                  0.0132                284407
 94.8                             TT3 DEG. RANKINE                            284407
PT9 PSIA                           976.2                                      284407
15.999                            TT9 DEG RANKINE       EPR                   284407
NET THRUST LBS                    1303.0                 6.46                 284407
2819.C                            N1 RPM                N2 RPM                284407
ACTUAL INLET PRESSURE PO PSIA     16802.                4435.                 284407
14.682                                                                        284407
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                      284407
522.4                                                                         2844C7
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           2844C7
 61.1                                                                         284407
FILTER AREA .385 SI                                                           2844C7
CLEAN CK SMOKE NUMBER 0                                                       284407
SMOKE NUMBER          VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH    284407
         10.9                  3.0          C.50    10.298           74.0     284407
         14.9                  4.0          0.50    10.298           74.0     284407
         18.7                  7.0          C.50    10.298           74.0     284407
         29.2                 11.0          C.50    10.298           74.0     284407
GASEOUS EMISSIONS                                                             284407
                   FID        NDIR        NDIR        CHEMI       CHEMI       284407
                   UHC        CO          CO2         NO          NOX         284407
RANGE               1          1           2           2           2          284407
INSTR GAS TEMP     154.       51.         51.         60.         60.         284407
RAW VALUE MV         2.7     532.C       620.6       467.2       537.9        284407
GAS CONCEN PPM(C)     2.7      49.6      27372.3        49.3        56.8      284407
GAS CONCEN PCT     C.CCC3     0.0050      2.7372      0.0049      0.0057      284407
EMISSION INDEX      0.10         3.6      3151.          5.9         6.8      284407
FUEL-AIR RATIO     C.0134                                                     284407
                                                                              284407
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ENGINE TEST DATA                                                                    283307
DATE                           DATA POINT         TEST CELL                         283307
08/16/76                       283307             13                                283307
INSTRUMENT OPERATOR                                                                 283307
ERHARDT                                           TEST OPERATOR                     283307
ENGINE MANUFACTURER                               TREMBLEY                          283307
LYCOMING                       MODEL              SERIAL NUMBER                     283307
FUEL IDENT.                    ALF-502            LF02                              283307
JET-A HC RATIO 0.161           FUEL FLOW PPH      MANIFOLD FUEL TEMP FAH            283307
BELLMOUTH AIR FLOW LB/SEC       778.              214.9                             283307
134.3                          CORE AIRFLOW LB/SEC FUEL-AIR RATIO MEAS.             283307
PT3 PSIA                       19.4               0.0111                            283307
 73.2                          TT3 DEG. RANKINE                                     283307
PT9 PSIA                        905.2                                               283307
15.503                         TT9 DEG RANKINE    EPR                               283307
NET THRUST LBS                 1203.0              4.98                             283307
1806.0                         N1 RPM             N2 RPM                            283307
ACTUAL INLET PRESSURE FC PSIA  15466.             3619.                             283307
14.689                                                                              283307
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                            283307
522.8                                                                               283307
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                 283307
 62.5                                                                               283307
FILTER AREA .385 SI                                                                 283307
CLEAN CK SMOKE NUMBER 0                                                             283307
SMOKE NUMBER        VOL.-LITERS    FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH              283307
         4.5               3.0         0.50      10.299               73.0          283307
         8.8               4.0         0.50      10.299               73.0          283307
        10.9               7.0         0.50      10.299               73.0          283307
        16.8              11.0         0.48      10.299               73.0          283307
GASEOUS EMISSIONS                                                                   283307
                   FID        NDIR        NDIR       CHEMI       CHEMI              283307
                   UHC        CO          CO2        NO          NOX                283307
RANGE              1          2           2          2           2                  283307
INSTR GAS TEMP     154.       56.         56.        60.         60.                283307
RAW VALUE MV        13.4      301.1       530.9      298.9       379.8              283307
GAS CONCEN PPM(C)    11.0      123.6       22880.3     31.5         40.1            283307
GAS CONCEN PCT     0.0011     0.0124      2.2880     0.0032      0.0040             283307
EMISSION INDEX      0.48      10.8        3139.        4.5         5.8              283307
FUEL-AIR RATIO     0.0112                                                           283307
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ENGINE TEST DATA                                                              282207
DATE                             DATA POINT           TEST CELL               282207
08/16/76                         282207               I3                      282207
INSTRUMENT OPERATOR                                   TEST OPERATOR           282207
ERHARDT                                               TREMBLEY                282207
ENGINE MANUFACTURER              MODEL                SERIAL NUMBER           282207
LYCOMING                         ALF-502              LF02                    282207
FUEL IDENT.                      FUEL FLOW PPH        MANIFOLD FUEL TEMP FAH  282207
JET-A HC RATIO 0.161              442.                170.0                   282207
BELLMOUTH AIR FLOW LB/SEC        CORE AIRFLOW LB/SEC  FUEL-AIR RATIO MEAS.    282207
 81.2                            11.4                 0.0108                  282207
PT3 PSIA                         TT3 DEG. RANKINE                             282207
 39.9                             740.1                                       282207
PT9 PSIA                         TT5 DEG RANKINE      EPR                     282207
14.986                           1215.5                2.71                   282207
NET THRUST LBS                   N1 RPM               N2 RPM                  282207
 608.0                           12092.               2157.                   282207
ACTUAL INLET PRESSURE PO PSIA                                                 282207
14.714                                                                        282207
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                      282207
522.9                                                                         282207
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                           282207
 63.3                                                                         282207
FILTER AREA .385 SI                                                           282207
CLEAN CK SMOKE NUMBER 0                                                       282207
SMOKE NUMBER        VOL.-LITERS     FLOW-CFM  PRESS.-PSIA  TEMP. DEG.FAH      282207
       2.3                 3.0         0.48      10.298           72.0        282207
       2.3                 4.0         0.50      10.298           72.0        282207
       4.5                 7.0         0.50      10.298           72.0        282207
       6.7                11.0         0.50      10.298           72.0        282207
GASEOUS EMISSIONS                                                             282207
                    FID        NDIR       NDIR       CHEMI      CHEMI         282207
                    UHC        CO         CO2        NO         NOX           282207
RANGE                1          2          2          1          1            282207
INSTR GAS TEMP      154.       58.        58.        60.        60.           282207
RAW VALUE MV         94.4      785.9      523.9      554.8      974.2         282207
GAS CONCEN PPM(C)     73.4      385.6    22537.5       13.8       24.0        282207
GAS CONCEN PCT      0.0073     0.0386     2.2537     0.0014     0.0024        282207
EMISSION INDEX       3.19       33.7      3054.         2.0        3.4        282207
FUEL-AIR RATIO      0.0112                                                    282207
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ENGINE TEST DATA                                                                   281117
DATE                                                                               281117
08/16/76                      DATA POINT                                           281117
INSTRUMENT OPERATOR           281117               TEST CELL                       281117
ERHARDT                                            13                              281117
ENGINE MANUFACTURER                                TEST OPERATOR                   281117
LYCOMING                      MODEL                TREMBLEY                        281117
FUEL IDENT.                   ALF-502              SERIAL NUMBER                   281117
JET-A HC RATIO 0.161          FUEL FLOW PPH        LF02                            281117
BELLMOUTH AIR FLOW LB/SEC      365.                MANIFOLD FUEL TEMP FAH          281117
 65.8                         CORE AIRFLOW LB/SEC  158.4                           281117
PT3 PSIA                       9.1                 FUEL-AIR RATIO MEAS.            281117
 32.4                         TT3 DEG. RANKINE     0.0112                          281117
PT9 PSIA                       690.6                                               281117
14.888                        TT9 DEG RANKINE      EPR                             281117
NET THRUST LBS                1240.6                2.20                           281117
 391.0                        N1 RPM               N2 RPM                          281117
ACTUAL INLET PRESSURE PO PSIA 10552.               1771.                           281117
14.712                                                                             281117
ACTUAL INLET TEMPERATURE TO DEG. RANKINE                                           281117
523.0                                                                              281117
SPECIFIC HUMIDITY GRAINS/LB DRY AIR                                                281117
 63.3                                                                              281117
FILTER AREA .385 SI                                                                281117
CLEAN CK SMOKE NUMBER 0                                                            281117
SMOKE NUMBER      VOL.-LITERS      FLOW-CFM PRESS.-PSIA  TEMP. DEG.FAH             281117
      0.0                 3.0          0.50      10.299           72.0             281117
      0.0                 4.0          0.50      10.299           72.0             281117
      2.3                 7.0          0.48      10.299           72.0             281117
      2.3                11.0          0.48      10.299           72.0             281117
GASEOUS EMISSIONS                                                                  281117
                   FID        NDIR       NDIR       CHEMI      CHEMI               281117
                   UHC         CO         CO2        NO         NOX                281117
RANGE               2          2          2          1          1                  281117
INSTR GAS TEMP     154.        58.        58.        60.        60.                281117
RAW VALUE MV        15.8      963.1      527.7      447.1      857.4               281117
GAS CONCEN PPM(C)  121.7      492.4    22669.2       11.3       21.4               281117
GAS CONCEN PCT     0.0122     0.0492     2.2669     0.0011     0.0021              281117
EMISSION INDEX      5.23      42.5       3074.       1.6        3.0                281117
FUEL-AIR RATIO     0.0113                                                          281117
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